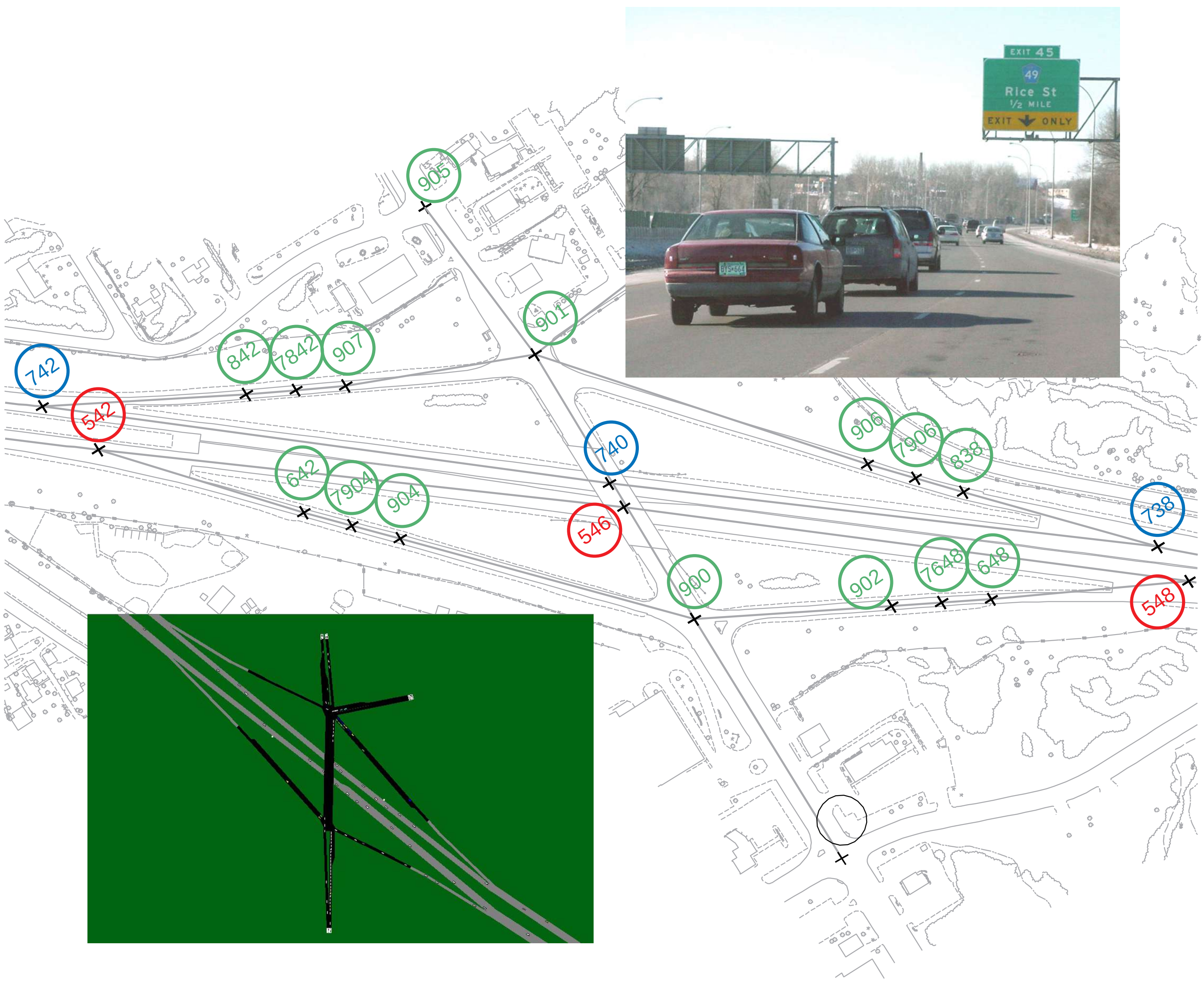
Advanced CORSIM Training Manual

Prepared by:

SEH



Prepared for:

MINNESOTA DEPARTMENT OF TRANSPORTATION

Hennepin County

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Advanced CORSIM Training Manual

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Appendix A General Modeling Guidelines

Advance CORSIM Training Manual

Prepared for Minnesota Department of Transportation, Federal Highway Administration, and Hennepin County

1.0 Chapter 1 – Modeling Process

The modeling process and guidelines contained in this manual are intended for project work requiring operational analysis using CORSIM (CORridor SIMulation) traffic software that requires Minnesota Department of Transportation (Mn/DOT) and Federal Highway Administration (FHWA) approval. This manual contains requirements for modeling a freeway project including; model development, input documentation, output documentation, and statistical requirements. This document is also a training manual that provides guidance on how to efficiently and effectively create CORSIM models.

1.1 Manual Purpose

This manual should not be read like a "mystery novel", where the user waits until the end of the book to see how the process ends. Before attempting to do a project for the first time using this manual, review the entire manual. Do not go directly to Chapter 4 and follow the steps of preparing a model. Chapters 5 and 6 provide guidance on documentation and calibration that are essential for preparing the model into the final product.

The purpose of this manual is to:

1. Document Mn/DOT's CORSIM modeling requirements.
2. Document Mn/DOT's criteria for developing CORSIM models.
3. Provide examples for how to construct a CORSIM model that satisfies the requirements and criteria.
4. Provide an approach to the calibration process.
5. Provide examples of how to document CORSIM modeling projects
6. Provide guidelines on conducting alternatives analysis.

This manual has been structured to mirror a FHWA process manual for micro-simulation modeling. The FHWA guidelines will provide general criteria that pertain to all micro-simulation modeling. The Mn/DOT CORSIM Freeway Modeling Manual is intended to provide specifics to modeling freeway corridors using CORSIM. The FHWA manual will provide complimentary information to the Mn/DOT manual.

1.2 CORSIM Model

CORSIM is a micro-simulation program developed by the FHWA. It is a program that has evolved over time from two separate traffic simulation programs. The first program, NETSIM or TRAF-NETSIM, is an arterial analysis program that models arterials with at-grade intersections. The second program, FRESIM, is a freeway model that models uninterrupted facilities including grade separated expressways and interstate freeways. CORSIM combined these two programs in order to have the ability to analyze complete systems. The effects of traffic operations between freeways and signalized ramp terminal intersections can be analyzed directly as opposed to analyzing the two facility types and “guessing” the potential impacts one type of facility has on the other.

CORSIM was developed for use in 1996; however, NETSIM and FRESIM are older programs that were developed and widely used well before CORSIM was available. One advantage of the CORSIM software is that it has been refined based on input from a number of different users from around the country. A number of problems have been identified and corrected as a result.

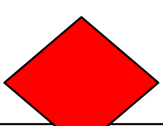
The reason micro-simulation models are used over other methods and software packages like Highway Capacity Manual (HCM) is that micro-simulation models allow us to evaluate the effects that different elements have on each other. Effects like, closely spaced intersections and interchanges or the effects of a bottleneck condition on the surrounding system. Also, as metropolitan traffic conditions experience congestion over 3 to 4 hour periods, the simulation programs allow us to evaluate the build up to congested conditions and the recovery of the system at the end of the period. The peak period of congestion is complex and evaluating solutions under these conditions can only be accomplished using micro-simulation tools like CORSIM.

1.3 The Modeling Process

The model process is outlined in the Figure 1. This process has been developed by FHWA and is based on the best practices of simulation modeling from across the country. The process provides a clear direction in how models should be developed, where does the calibration process occur, and at what point the alternatives analysis process is appropriate.

Unsuccessful modeling projects are projects that exceed budgets, take too long, and/or result in a model that lacks credibility. The closer the modeler adheres to a process, one that is widely accepted, the more likely major problems will be avoided, and if necessary, can be corrected with outside assistance. This manual was written with this process in mind.

One principal of preparing simulation models is to incorporate reviews at logical steps during the process. The following symbol will be used throughout this manual to indicate a point in the process that an independent review takes place.



Review Symbol:
Deliverable or type of review will be identified

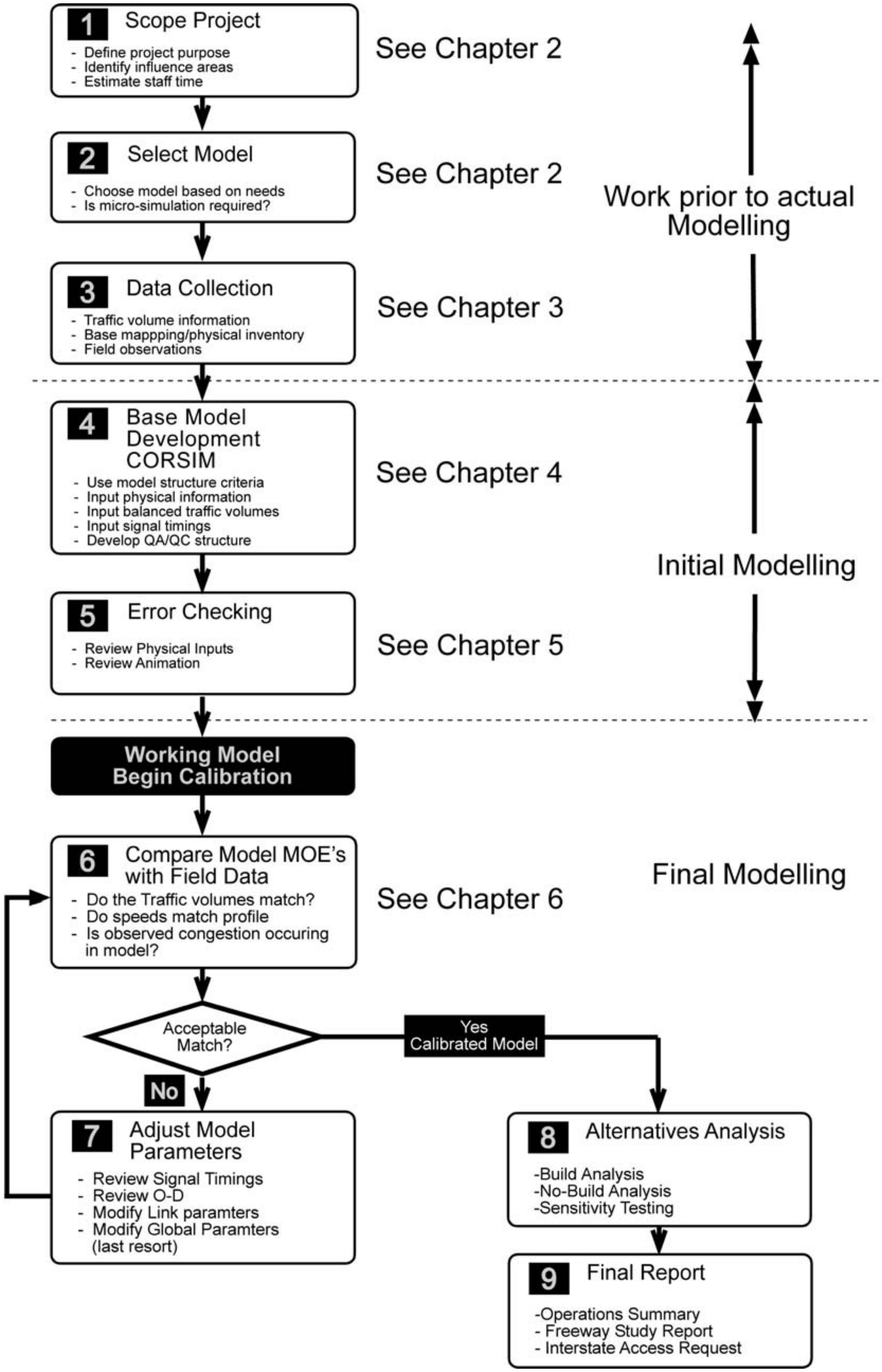


Figure 1 – Modeling Process Flow Chart

1.3.1 Goals of a Good Modeling Process

There are many ways of defining what a good modeling process is. A lot of what goes into the definition depends on the purpose of the project. Projects that require Mn/DOT and FHWA approval are usually interstate freeway projects. These types of projects tend to be very expensive and must not only satisfy local needs, but must satisfy the needs of interstate travel. Because of the importance of these projects, it is imperative that the following goals be kept in mind while preparing a simulation model for a project.

- **The model must be accurate.** Evidence needs to be provided that the model is indeed accurate. For instance, tying in the model to real world coordinates is a way to make the model more accurate.
- **The model must be reproducible.** Reproducibility in a modeling process is an important concept because there are many different ways that a "model" can be developed, and as a result, different conclusions may be reached. To ensure that conclusions are properly made, the model needs to be developed and documentation prepared that would allow an independent modeler to recreate the same model from the source data. From this common start point, the project team or independent reviewer will be able to evaluate if the finer points of the model or the calibration parameters should have been coded differently.
- **The modeling process needs to be efficient.** CORSIM models are essentially large electronic databases of information. Due to the variability of traffic forecast information and travel pattern information, it is important to evaluate projects under different traffic conditions to determine design sensitivity. If the model has been prepared in an efficient manner, the ability to evaluate different design and traffic conditions is more feasible and cost effective. If the model has been prepared using inefficient manual methods, the real value of using micro-simulation, as a design and evaluation tool, is lost.
- **The modeler must always keep the end in mind.** Preparing traffic models can be quite complex, and at times, a modeler can be completely engrossed in details and lose sight of the big picture. In the beginning of the modeling process, starting with the project scoping and data collection through the model development, a lot of information is compiled and developed that will assist in developing solutions and providing results. Every spreadsheet, sketch, and note is a valuable piece of information that is developed along the way and has value to the project; however, early in the process, this may not be evident. Think with the end in mind during the process, and rework will be minimized because that great thought or spreadsheet you developed at the beginning and threw away could be used later on.

1.4 Model Support Information On-line

Mn/DOT's web site has a number of sample files and support files for conducting CORSIM simulation studies. These files include CORSIM input files, fleet information in the required CORSIM format. Sample tables and graphics, as well as a complete model manual are available. The web site is:

www.mn.com

2.0 Chapter 2 – Project Scoping

Identifying the project limits and the model to be used on any project should be given careful consideration. The variety of projects that are typically conducted in Minnesota range from high level planning studies to project development to research. Each of these types of studies will have different levels of need for traffic analysis. Planning efforts may only require capacity analysis to determine the basic number of lanes, whereas project development type studies may have varying degrees of modeling requirements based on the location (urban versus rural) and the type of facility (interstate freeway versus trunk highways).

Before a project begins, a meeting should be held with the project manager, FHWA representative, and Mn/DOT traffic modeling expert to determine the scope of project including the model limits and time periods. This chapter provides an overview and guidance as to what should be considered in developing the scope for modeling a project.

Kick-off meeting with
FHWA and Mn/DOT

2.1 Scoping Steps

The steps in scoping a modeling project begin with the purpose of the project. Is the project a new access to the interstate system, or is it a modification to an existing interchange? Where is the project located? Is it out-state or in the metro area? If it is in the metro area, is it near a systems interchange? These are the types of discussion questions that need to be considered when scoping the project. The following subsections will provide information and things to consider when scoping. The process will, in some fashion, use the following steps:

Step 1: Identify Project Purpose

Step 2: Identify Limits of Analysis

Step 3: Select Model

Step 4: Estimate Data Collection Requirements

Step 5: Estimate Level of Effort

Step 6: Sensitivity Analysis

2.1.1 Step 1: Identify Project Purpose and Need

The purpose of the project goes a long way towards determining the scope of a traffic analysis. The first consideration is the type of project. Is the project a high level planning study that requires minimal analysis to determine basic roadway sizing, or is the study researching ramp meter strategies? The types of projects that this manual addresses are changes to the interstate freeway system, either new access or a modification to an existing interchange. These types of projects will have a tight turn around because the subject interchange typically will be designed and constructed in the immediate future.

2.1.2 Step 2: Identify Limits of Analysis

Once the purpose has been identified, careful consideration and deliberation is given to identifying limits to the modeling effort. The model limits are determined as early as possible in the design process. A meeting with FHWA, Mn/DOT's freeway modeling group, and the project manager should occur early to discuss the modeling limits. The discussion will involve identifying the area of influence around the project and to identify the boundary conditions.

2.1.2.1 Influence Areas

The area of influence around the project includes adjacent interchanges that could be affected by the construction of the proposed project or future improvements to adjacent interchanges that could have an effect on how the proposed project is constructed. The influence area is close to the project and is based on the potential influence of the proposed construction. One of the requirements for access approval is to demonstrate that the proposed interchange project is compatible with the interstate plan. Therefore, the influence area includes at least one interchange on either side of the proposed interchange project. In the metro area where interchanges are closely spaced, the influence area may extend beyond the adjacent interchanges.

2.1.2.2 Boundary Conditions

Boundary conditions are the limits to the model. Depending on the project location, the boundary condition could be the same as the influence area or it can extend beyond the influence area. Boundary conditions that extend beyond the influence area typically occur in very congested areas of the metro area. Due to the congestion, extended model limits are needed so that traffic conditions within the influence area can be replicated.

Determining boundary is based on the following:

- **Entering the influence area.** The boundary condition limits should be based on: where backups begin, ramp connections that affect weaving within the influence area, and any other operational situations.
- **Leaving the influence area.** The boundary condition limits should be based on: downstream congestion that backs up into the influence area, ramp connections that affect weaving within the influence area, and other operational situations.

Generally, the modeling limits for projects in out-state areas include one interchange on either side of the proposed construction project. Figure 2 illustrates this condition. Within the metro area, the model limits for a proposed project need to consider adjacent systems interchanges. Depending on the proximity of the proposed project to a systems interchange, the entire systems interchange may need to be modeled including portions of the intersecting freeway. Modeling systems interchanges, whether it is part of the analysis or if it is the subject of the analysis, needs to consider the "tails" of the freeways leading into it. Figure 3 illustrates metro modeling limits.

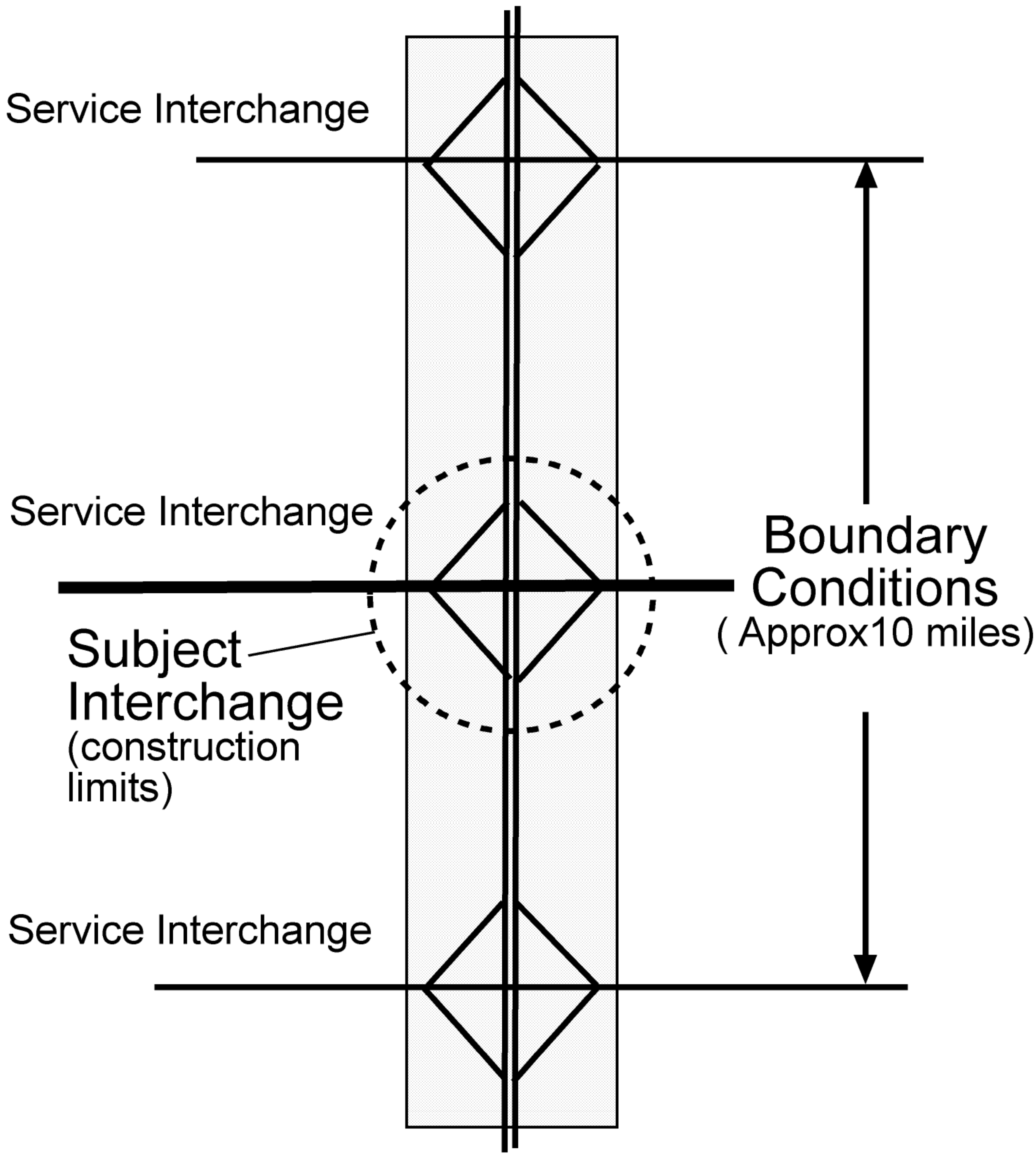


Figure 2 – Out-State Modeling Limits

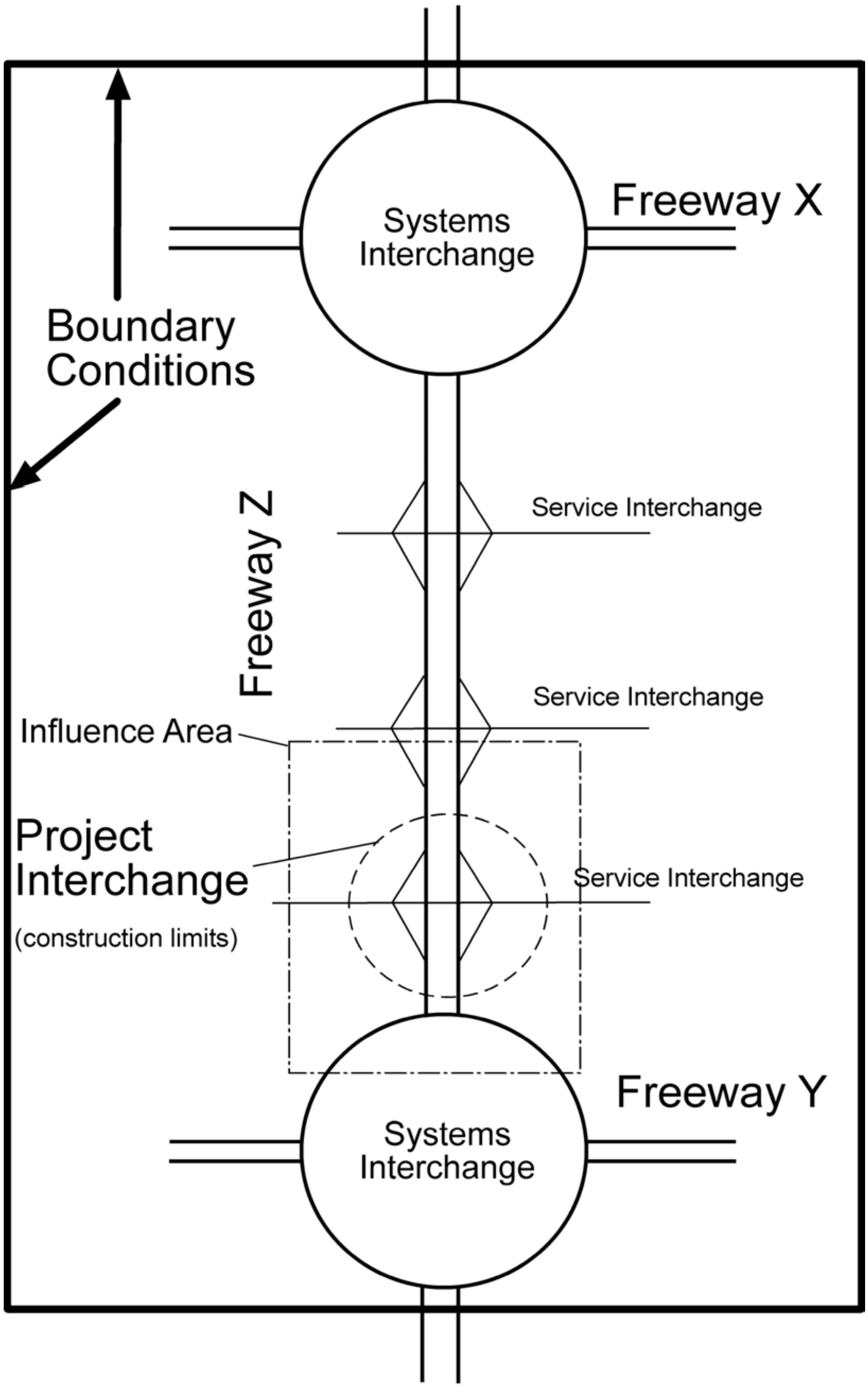


Figure 3 – Metro Modeling Limits

2.1.2.3 Choosing Model Time Periods

The length of the modeling period relates to the location of the project and the type of congestion that is experienced. Within the metro area, the congestion levels extend well beyond the peak hour. Based on modeling experiences in the last few years, it has become clear that the modeling period must be two to three hours to replicate congestion. Within the longer time periods, traffic flow rates must be adjusted every 15 minutes to reflect the build up to congestion and the recovery afterwards. Figure 4 below illustrates peak period conditions for I-35W near downtown Minneapolis. In out-state areas, peak traffic conditions could be less than one hour; in these cases, a single peak hour may be modeled.

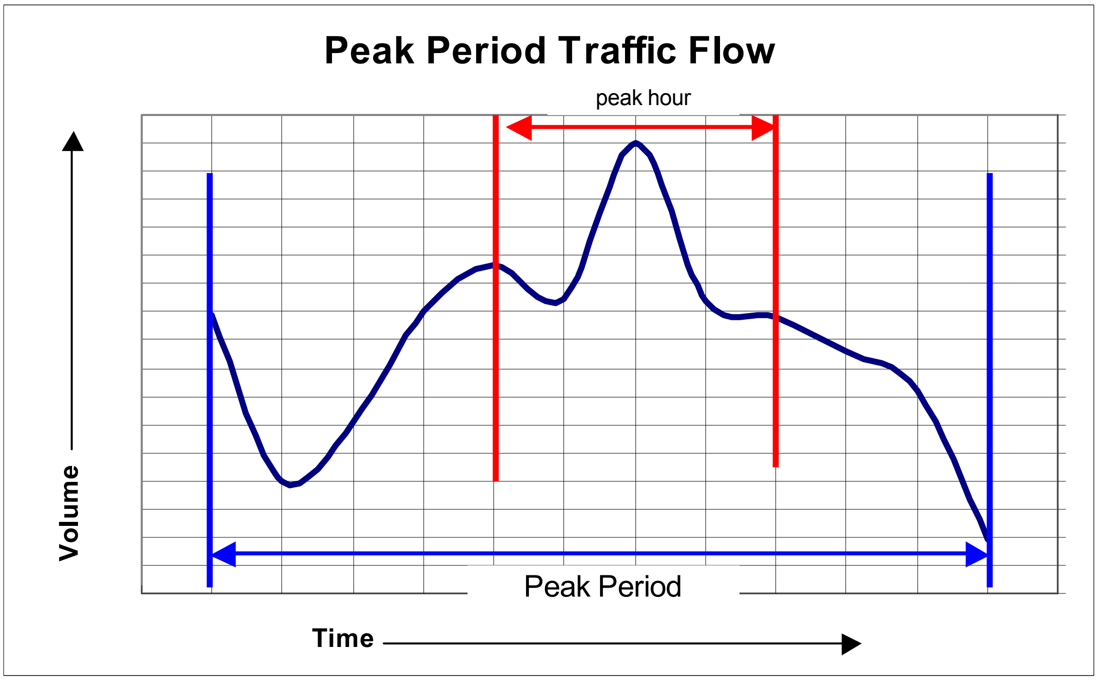


Figure 4 – Modeling Time Periods Sample

2.1.3 Step 3: Select Model

Selecting the appropriate model to use can depend on the purpose of the project as much as the complexity of the project. Also, within a project, multiple analysis methods may be used to provide a comparison or to initiate preliminary design work that will be analyzed in detail further into the study.

HCM techniques provide a good assessment of basic lane needs and provide an indicator of whether individual elements will operate adequately or not. If the HCM levels are poor, the micro-simulation analysis will likely be poor. However, if there are complexities in the system, like multiple weave sections within an area, the HCM methodologies will likely overestimate operations. This is where the micro-simulation approach is essential in the analysis.

All freeway projects involving modified or new access within the metropolitan area will require a micro-simulation analysis. Out-state freeway projects may require a simulation analysis depending on existing and/or projected traffic levels. It could also depend on the proposed project. For instance, is it a new interchange within 5 miles of an existing interchange?

Based on the complexity and type of project, assess what model should be used. In most cases, projects relating to the interstate system will require micro-simulation analysis. However, it may be necessary to also conduct a Highway Capacity Software analysis early in the project to allow the design process to proceed. The simulation model will then be used to evaluate and refine this design.

2.1.4 Step 4: Estimate Data Collection Requirements

Data collection requirements are discussed in detail in Chapter 3. The type of information that needs to be collected for simulation modeling includes traffic count information broken down into 15-minute intervals.

Based on the analysis limits and model selected, identify all data required. This will include traffic counts, speed runs, and assembly of information.

2.1.5 Step 5: Estimate Level of Effort

The level of effort for conducting a traffic analysis project is important at many levels. When a Mn/DOT project manager is developing a scope for a project, there should be a way to convey expectations of what is involved. Typically, the existing calibrated CORSIM models should take at least one month to prepare. This could be more or less depending on the complexity of the project. This time does not necessarily translate to staff hours. One must consider if there is time to wait for information, and if there needs to be time allowed for review of link node diagrams and model inputs. This should occur in small steps as opposed to all at the end. Rework as a result of not catching mistakes early on in the process can double the time and effort.

2.1.6 Step 6: Sensitivity Analysis

Sensitivity analysis is conducted on the preferred alternative to identify the capacity of the alternative and to further fine-tune the design. The conditions for sensitivity testing are based on the needs of the particular project and conducted as an optional task. The types of sensitivity tests includes:

- **Traffic Forecast Sensitivity.** Traffic volumes can be increased or decreased to determine the capacity of the alternative and to determine break points in the system. It is possible that the proposed design at the break point and a small percentage increase in traffic causes failure. Identifying these break points could be used to refine the design.

- **Weaving Sensitivity.** The percentage of weaving traffic is typically estimated in simulation projects. Altering the weaving percentages can be used to identify the sensitivity of the design to weaving traffic.

- **Design Sensitivity.** Simulation models can be used to evaluate the effects of the design with and without auxiliary lanes or with different storage lanes and/or lengths can be conducted to fine tune the design.

2.2 CORSIM Modeling Schedule

A generic schedule for a CORSIM modeling project by major tasks has been developed as a guide to understanding the scoping process (Figure 5). This scope may not have all of the subtasks that are required so the work breakdown schedule needs to be considered on a project-by-project basis. The length of the project will be dictated by the size and complexity of the project. However, for most projects, this process will be between three and six months.

2.2.1 Pitfalls in Modeling Process

Complex systems interchange areas usually involve unusual design and operational characteristics that are difficult to model. In these cases, you need to account in the budget and schedule that recoding of parts of the model may be required. The standard coding templates included in this manual may not apply to the unusual circumstances. There have been a number of projects in the Twin Cities metro area where unusual conditions required special coding that was **not** fully understood until the modeling was prepared. These projects are a valuable resource and are available for review. The projects include: I-694/I-35E interchange (unweave the weave area), the I-35W/TH 62 Crosstown Commons, and the Lake St. access project, and the coding of the I-35W/I-94 downtown commons area.

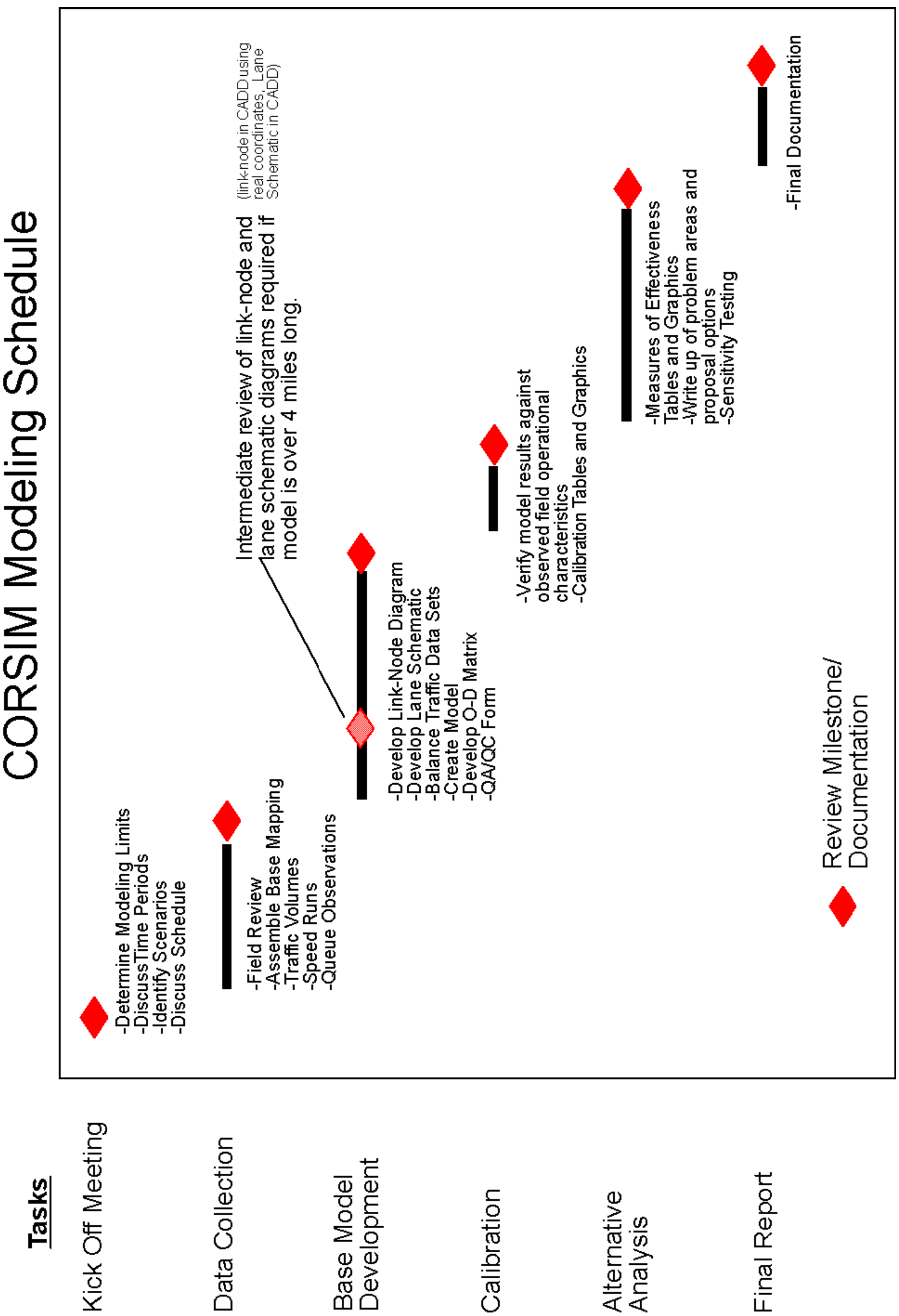


Figure 5 – CORSIM Modeling Schedule

3.0 Chapter 3 – Data Collection

Data collection for CORSIM freeway studies need to be conducted to match modeling requirements as defined in the project scoping process. The type of information that needs to be gathered includes information for model setup (traffic volumes, geometry, signal timings) and for model calibration (observed speeds, traffic queuing). This information should be completely gathered before the CORSIM model is created. The following chapter will describe the data requirements, provide some examples, and make reference to other manuals that describe data collection techniques in further detail.

3.1 Base Mapping

Good base mapping can make the difference between a successful start to a model or a disaster that you never recover from. Mn/DOT has very good base mapping available for the freeway system from which a model can be prepared. If the project is in the preliminary engineering phase, the base mapping will be assembled, and the proposed concepts will be drawn out in CAD.

3.2 Field Review

After a base map and modeling limits have been discussed, the modeler should drive through the project area during peak conditions. The purpose of this initial viewing of the project is to identify hot spot locations, apparent visual cues that affect operations. A set of notes should be assembled to document these observations. The field review will occur throughout the modeling process, especially during the calibration process. While trying to calibrate the model, it is possible that the real cause of congestion is not apparent; the animation output may cause you to question why congestion is occurring. Going out in the field to re-review conditions with more specific questions may be the only way to resolve the issue.

The Traffic Management Center (TMC) surveillance cameras are useful for making observations; the camera surveillance should be used to supplement the field review. One problem with relying solely on the cameras for field review is the limitations of the field of view of the cameras. The cameras are a 2-D image and may not capture what the cause of the congestion.

Depending on the location, it may be useful to get out of the car and stand on a bridge or overpass to observe operations. In particular, at ramp junctions to observe how drivers are responding to entering vehicles. Do drivers on the freeway move out of the way or yield to entering traffic? If so, where do they change lanes? Are vehicles using the shoulder? At on ramp locations with auxiliary lanes, are drivers using the full lane to accelerate or are they changing lanes at the first opportunity?

These questions and what the observations will direct the calibration process. The way drivers in the real world use the road system can be very different within the same model. The modeler must be aware of these potential differences and document them so they can be incorporated properly into the model.

3.3 Traffic Volumes

Traffic volumes are essential to traffic modeling. Without traffic volumes, there is no traffic model. Collecting traffic volume data for freeway studies in Minnesota can be divided into two areas, traffic data from the instrumented system and traffic data from the un-instrumented system. Collecting data from the instrumented system is straightforward, accurate, and efficient. Gathering freeway data on the un-instrumented system is a manual process that requires more effort and is more costly. In both cases, great attention needs to be given to balancing traffic counts. Traffic must balance in order for the CORSIM model to run as expected and to be calibrated.

The requirements for traffic count information to be collected are:

- Traffic volumes on the freeway for morning and evening peak 3-hour period as identified in the scoping process.
- Turning movement counts at ramp terminal intersections should not be older than 2 years, and must include the 3-hour peak periods.
- All counts should be summarized by 15-minute intervals.

For the metro area, the month of October has been selected as the month that is the most representative of the conditions for which design should occur. Data pulls for CORSIM modeling projects on the instrumented system should be done for the month of October.

3.3.1 Instrumented System

Gathering count information from the instrumented system is done by identifying all the count stations and detectors within the model limits and providing a list of the stations/detectors to Mn/DOT's TMC representative responsible for data requests. These counts should be requested with mainline detectors and on and off ramps in sequence. For instance, the first station would be the beginning of the mainline freeway, followed by the next ramp, followed by the next mainline station, followed by the next mainline station, etc. The information pertaining to detectors is contained in the All Detector Report (ADR). Figure 6 below is the detector legend from the ADR; the rest of the ADR is divided by facility.

Data from the instrumented system needs to be cross-referenced against incident reports and weather conditions. Traffic data used for the model should reflect the highest amount of traffic that can get through the system on a normal day. In some areas of the metro, it will be very difficult to find a normal day free of incidents and inclement weather. If such data cannot be found in the initial data request, request data for different days.

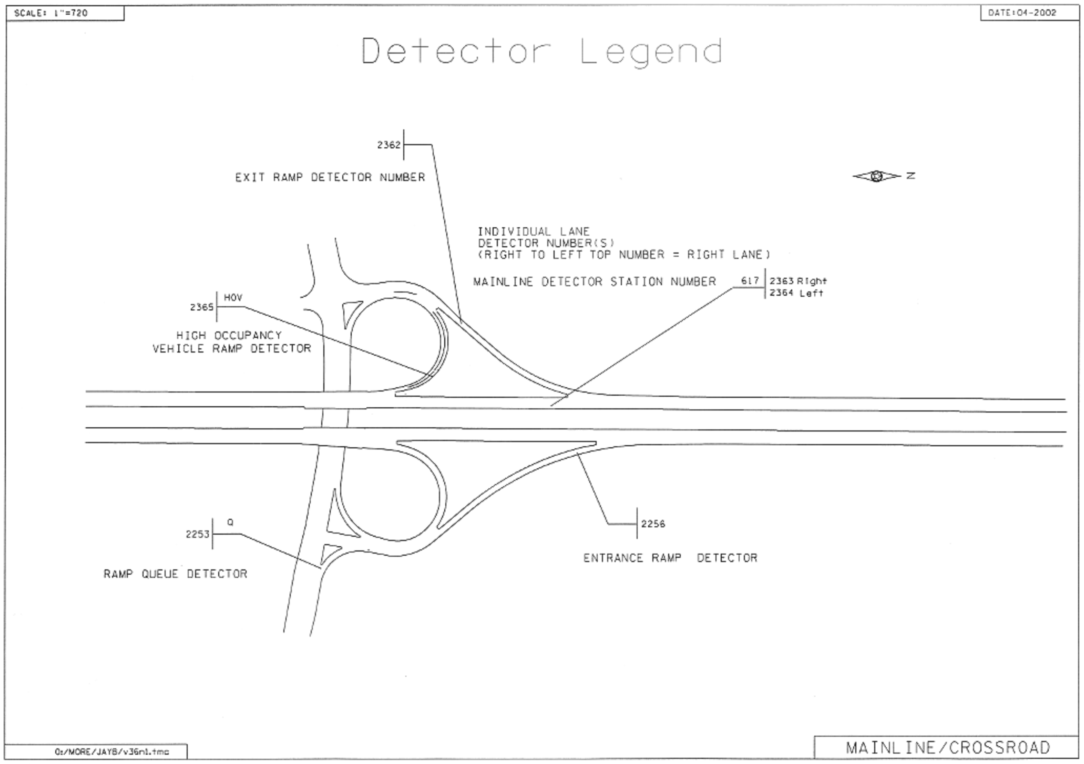


Figure 6 – ADR Detector Legend

3.3.2 Un-instrumented System

Collecting traffic counts on the freeway system where there is no instrumentation can be very costly. It is important that the modeling limits are thought through very carefully, because going back to collect more information later creates other discrepancies. The goal of collecting data on the un-instrumented system is to collect as much data as possible at the same time. Tube counts on the mainline should be done in at least two places in the event that the tubes are ripped. All ramps within the study should be counted simultaneous with the mainline counts, either with tubes or with manual turning movement counts at the ramp terminal intersections. Balancing counts that were taken at the same time is much easier balancing than counts that were collected at different times.

3.3.3 Intersection Turning Movement Counts

Off the freeway system at ramp terminal intersections and other adjacent intersections traffic information is gathered by manual turning movement counts. Mn/DOT collects these counts on a periodic basis. However, if the data is more than two years old, the intersections should be recounted. If the study is being conducted on the un-instrumented system, the ramp terminal intersection counts can provide the on and off ramp count information.

3.3.4 Balancing Counts

Balancing traffic counts is an important traffic engineering skill that is essential in a micro-simulation process. Micro-simulation programs including CORSIM operate from the outside to the inside. What happens is the total numbers of vehicles are entered from the entry nodes at the perimeter of the model. As vehicles travel to the interior of the model, each individual vehicle is assigned a direction to take based on the turning percentages calculated at each junction. So even though the turning volumes in vph are entered at each junction, the values are converted into percentages. The model will not know whether or not the counts are balanced and will assign traffic according to the percentage.

The process for balancing counts is to review the data as a whole and identify traffic counts by direction that is not consistent with the surrounding data. For the freeway loop detector volumes on the instrumented system, identifying inconsistent data can be done by reviewing the detector summary graphs. These graphs will indicate from the system volume trends for all of the detectors and will provide an indication of the ones that are not working properly. Figure 7 below is a sample of speed flow information that can be used to review detector data.

In all cases, the traffic counts will have to be checked by starting at the beginning or perimeter of the system and add and subtract entering and exiting traffic. Along the way, the count information should match the counts from one station to the next. If it does not balance, a decision needs to be made on how to best reconcile the counts.

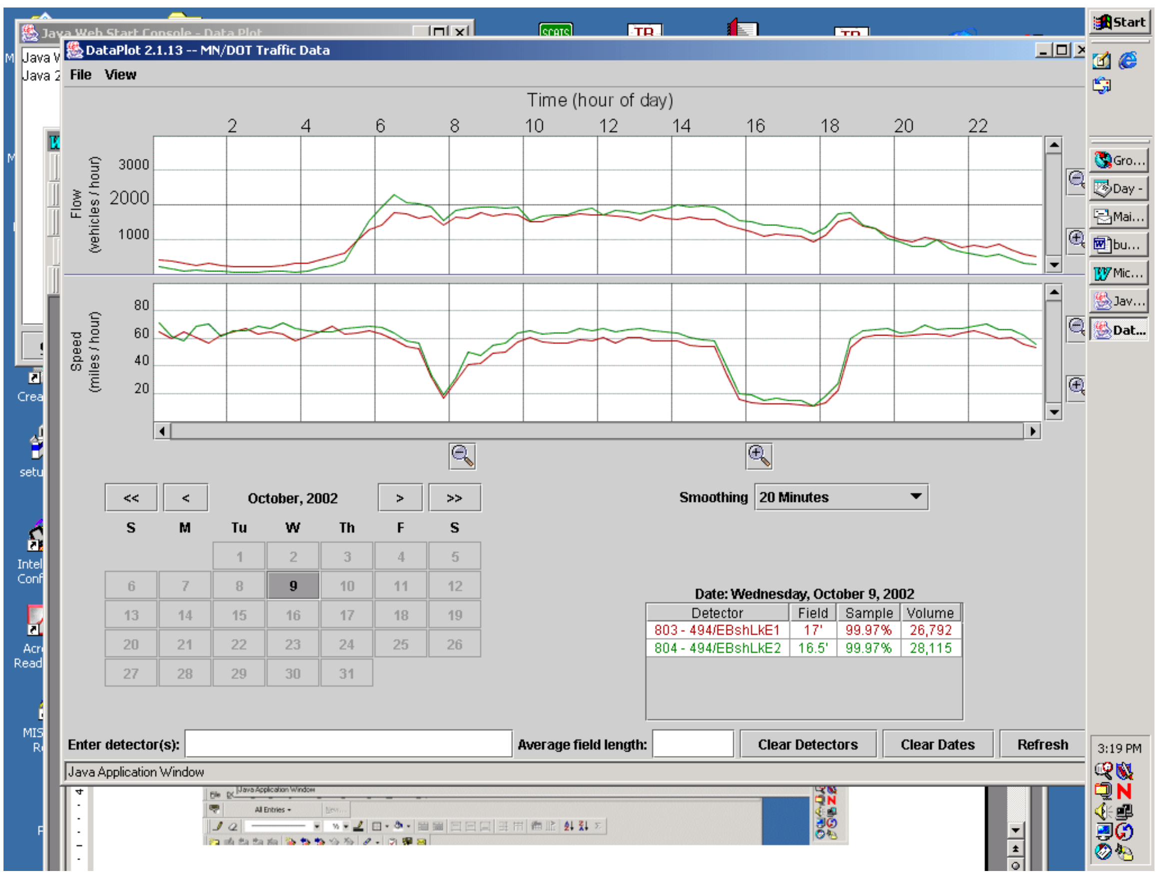


Figure 7 – Data Plot sample-Evaluating Detector Data

3.4 Speed Studies

Speed information is collected from the system in two ways. For the instrumented system, spot speeds at detectors can be gathered. The speed information taken from these detectors is derived and can be subject to error. To ensure that operations are clearly understood for both instrumented and un-instrumented systems, a speed study using the floating car method is required. The data collection requirements include at least 10 runs per freeway direction within the 3-hour peak period with 3 of these runs occurring within the peak hour.

Collecting speed study information using the floating car method can be done two ways. The first way, and preferred method, is to use an in vehicle recording device. PC Travel is a widely used product that does speed studies by recording the speed trajectory of the trip. The user will hit a button at select locations to identify benchmarks. Figure 8 is sample speed flow chart from PC Travel. The second method is a manual method in which a tester drives the freeway and documents the speed as key points are passed. Figure 9 is a sample data set summarized using this method.

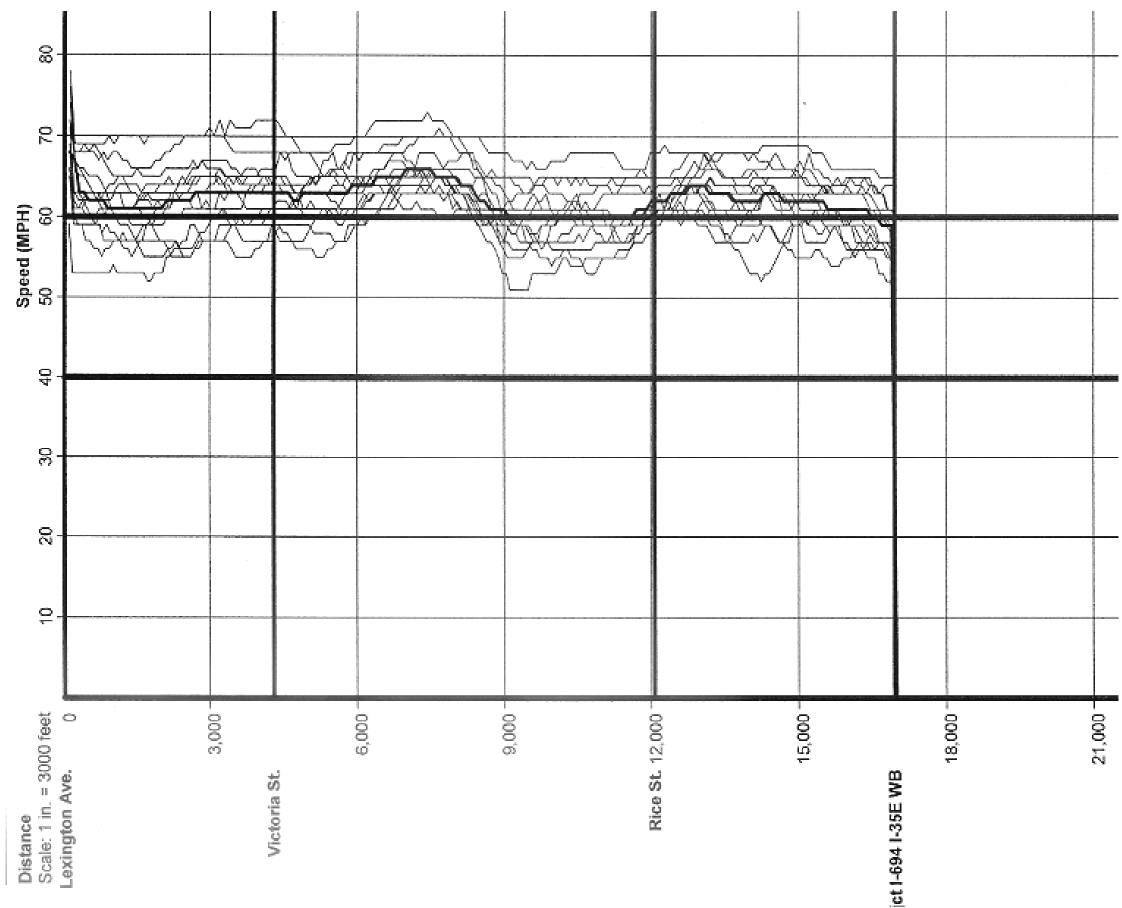


Figure 8 – Speed Study Graphic-PC Travel

description	distance between	cumulative length	Spot Speeds Start Time and Run Number				
			7:10 AM Run #1	7:22 AM Run #2	7:35 AM Run #3	7:40 AM Run #4	7:50 AM Run #5
Lexington Ave exit-ramp	0	0	15	25	22	25	30
Lexington Ave on-ramp	1880	1880	42	40	45	38	23
Victoria St Exit	3900	5780	50	52	48	46	51
Victoria St on-ramp	1500	7280	41	37	36	40	39
north rail bridge	4100	11380	55	58	53	51	58
Rice St exit	2200	13580	32	28	35	33	31
Rice St entrance	1950	15530	20	19	15	18	22
West Junction I-694	4200	19730	15	10	12	14	18

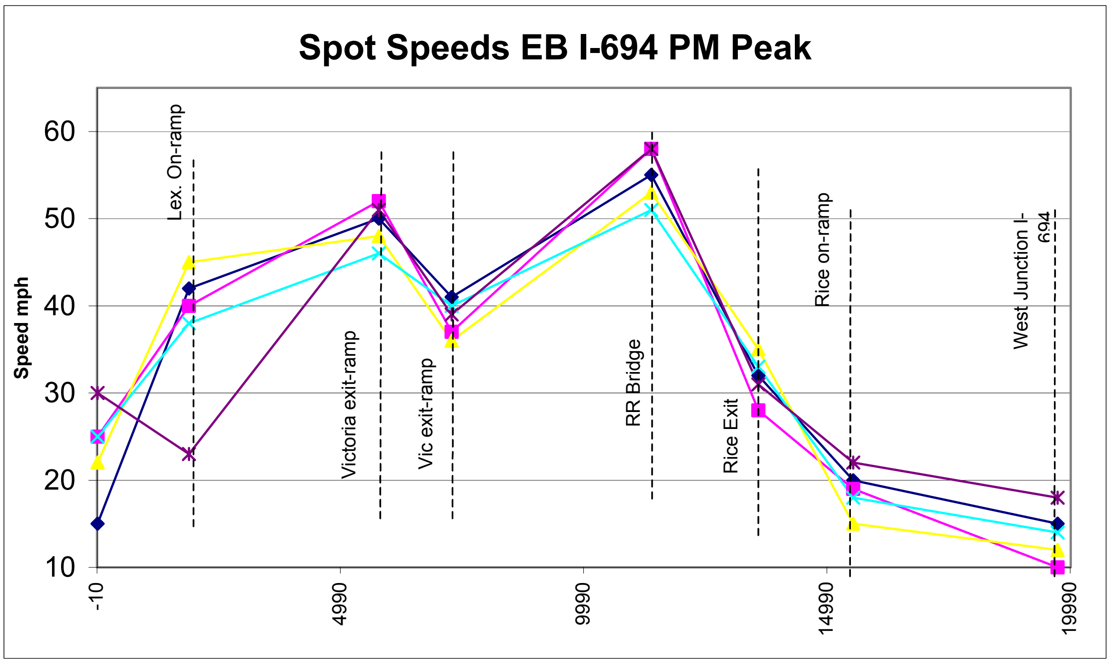


Figure 9 – Speed Study Sample-Manual Technique

3.5 Queue Observations

Queue observations are conducted at the ramp terminal intersections during the peak periods. The observations should be done to observe the maximum queues.

3.6 License Plate Origin-Destination Studies

License plate origin-destination (O-D) studies conducted on high-speed facilities are very difficult and expensive to do. This is not required for most projects because of the costs. However, if the study has contentious issues regarding weaving percentages and it is deemed necessary, then an O-D study should be conducted. The number of firms with the capability and technology to do this type of study is limited to one or two in the entire country. The equipment required to do the studies includes a number of high-speed video cameras (typical video recorders for home use will not work!) and data recognition software that will read the license plates automatically. Manually reading every license plate is not cost effective; also the software for reading the license plate can easily add a time stamp that is essential for calculating O-Ds.

4.0 Chapter 4 – Base CORSIM Model Process

4.1 Base CORSIM Modeling Process Overview

The CORSIM modeling process begins after the data has been assembled and prepared.

A successful simulation model is one that is:

- Verifiable
- Reproducible
- Accurate

The method for developing a CORSIM model that achieves these goals is a simple process that requires the modeler to think in terms of layers. Each individual layer in the model can be broken down into very manageable individual tasks that build towards the completed model. The analogy to consider is building a house. To build a house, you begin with a blueprint, and then you build each element in sequence, with each individual step being relatively straightforward. The construction sequence begins with the foundation, the framing, followed by the roof, walls, and finally the interior details. The development of a successful CORSIM model is similar in that you must begin with a link node diagram (blue print), and then you proceed to build the model in a sequence that breaks down the total model into basic steps. First, the link node structure is created in TRAFED (the frame of the building), followed by the addition of detailed attributes including operational characteristics and traffic volumes (interior details).

Another advantage to the process in this manual is the ability to break the model into independent parts. This will allow you to better utilize staff resources through multi-tasking activities. Parts of the model can be prepared separately and combined at the end to develop the completed model. In brief, the process is a four part process. The first part is the creation of the link node diagram and lane schematic. The second part is the creation of the freeway submodel (FRESIM), and the third part is the creation of the arterial submodel (NETSIM). The final part is combining the two submodels.

4.1.1 Long-Term Benefits to a Standardized Process

The long-term benefit of all CORSIM models in the State of Minnesota prepared using the criteria in this manual is threefold. First of all, the quality control and review of the model will be consistent reducing modeling mistakes and review time. Secondly, less time will be spent debating on how to model and more time will be spent on what is modeled. Finally, it becomes viable to reuse a model. This process and criteria were established so that a minimal amount of effort would be required to add to an existing model or to modify a model with a different design condition. To date, over 30 miles of the metro area freeway have been modeled using this criteria. Building models to the same coordinate correct system allows them to be expanded upon efficiently. Using different project coordinates for models would have the same difficulties that design projects have when different coordinate systems are used, adjoining projects will be incompatible with each other. Using the same coordinate system on recent projects has resulted in significant time and cost savings when new projects have expanded on existing models.

STOP! AND READ THIS!

Before proceeding with any model development, Chapter 5 should be reviewed to clarify file management and the required organizational structure of all files that are developed during the model development process.

4.1.2 Model Development Steps

Part I: Link Node Diagram and Lane Schematic Development

- Step 1: Create link node diagram and lane schematic
- Step 1a: Balance traffic data sets for the peak period and multiple time periods

Part II: Freeway Coding

- Step 2: Code freeway mainline nodes (direction 1)
- Step 3: Connect freeway mainline nodes (direction 1)
- Step 4: Code freeway ramp nodes (direction 1)
- Step 5: Connect freeway ramps with freeway mainline (direction 1)
- Step 6: Code physical and operational characteristics (direction 1)
- Step 7: Code peak hour traffic volumes (direction 1)
- Step7a: Verify the model function and operation and make changes to model structure to accommodate unique features
- Step 8: Translate and run direction 1 of model
- Step 9: Repeat steps 2-8 for direction 2 of the model
- Step 10: Repeat steps 2-8 for intersecting freeways
- Step 11: Combine freeway submodels
- Step 12: Create Quality Control/Quality Assurance (QA/QC) worksheet
- Step 13: Coding O-D information

Part III: Arterial Coding

- Step 2: Create a Synchro model of the ramp terminal intersections by interchange (one file for all interchanges).
- Step 3: Change node numbers and coordinates.
- Step 4: Update signal timings
- Step 5: Transfer Synchro file to CORSIM input file *.trf (CAUTION DO NOT NAME THE SYNCHRO FILE THE SAME AS THE FREEWAY FILE).
- Step 6: Run Synchro generated CORSIM file.

Part IV: Combining Models

- Step 1: Combine freeway and arterial *.trf files.
- Step 2: Connect the two models in TRAFED.
- Step 3: Run combined model.
- Step 4: Finalize QA/QC.
- Step 5: Develop input for multiple time periods.
- Step 6: Run model.
- Step 7: Summarize Measures of Effectiveness (MOEs) outputs.

4.2 Part I: Link Node Diagram Development

Step 1: Create Link Node Diagram and Lane Schematic

The link node diagram should be developed using real coordinates in CAD. The main reason for this is, in the freeway models, the details required to develop a model are not apparent on BMP or JPG files. Details, such as points of curvature, grades, and painted nose locations, are not readily apparent. Also, the modeler needs to “map out” the model ahead of time to ensure the structure of the link node diagram follows a logic that will make reviewing the model inputs efficient. It will also allow for multi-tasking model coding (i.e., there would be no node numbers repeated).

A detailed link node diagram is critical to the modeling process to ensure efficient review, to ensure that the model results are reproducible. Developing a good link node diagram at the beginning of the modeling process is essential to a successful project. The lane schematic or coding diagram is a drawing that when developed properly compliments the link node diagram and facilitates the model coding. The lane schematic diagram, if prepared electronically in CAD (a graphics program) or excel, can be used to illustrate model results. So essential are the link node diagram and lane schematic that a person preparing a model should never begin a model without a link node diagram and lane schematic. The only law to modeling is as follows:

Law # 1: Thou shall not begin a model without a link node and lane schematic.

What does this mean?

A link node diagram is not a sketch on a blank piece of paper that gets discarded after the model is set up. It is a diagram created on a base map in real world coordinates either on an aerial or topographic base mapping, which will be used to construct the CORSIM model. The link node diagram is sent along with the electronic input files when being reviewed. The lane schematic is a representation of the freeway system – not to scale – that allows the modeler to view how lanes are connected through the system and to identify acceleration and deceleration lanes and how they should be coded. Below are examples a link node diagram and lane schematic.

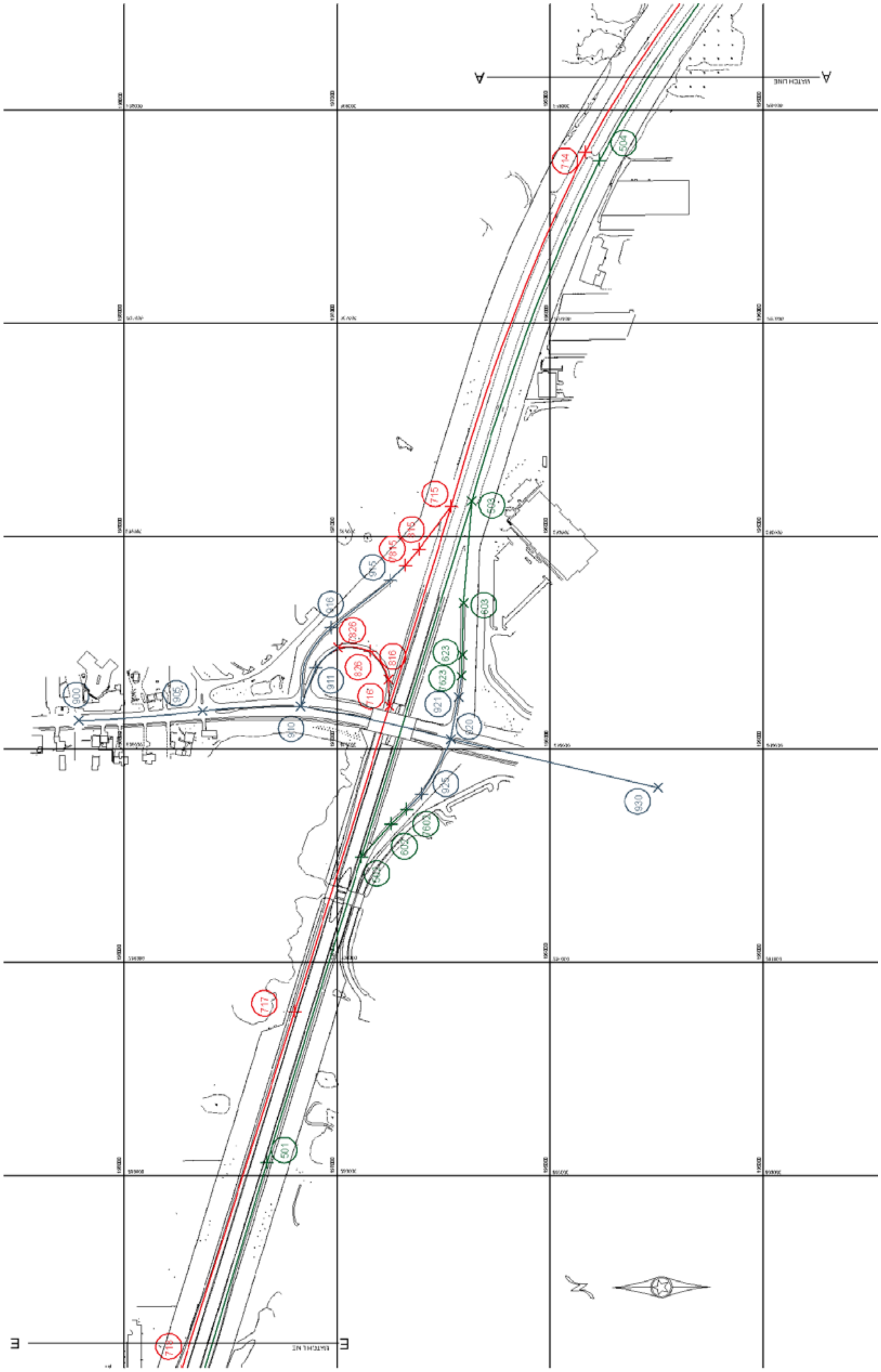


Figure 10 – Link Node Diagram

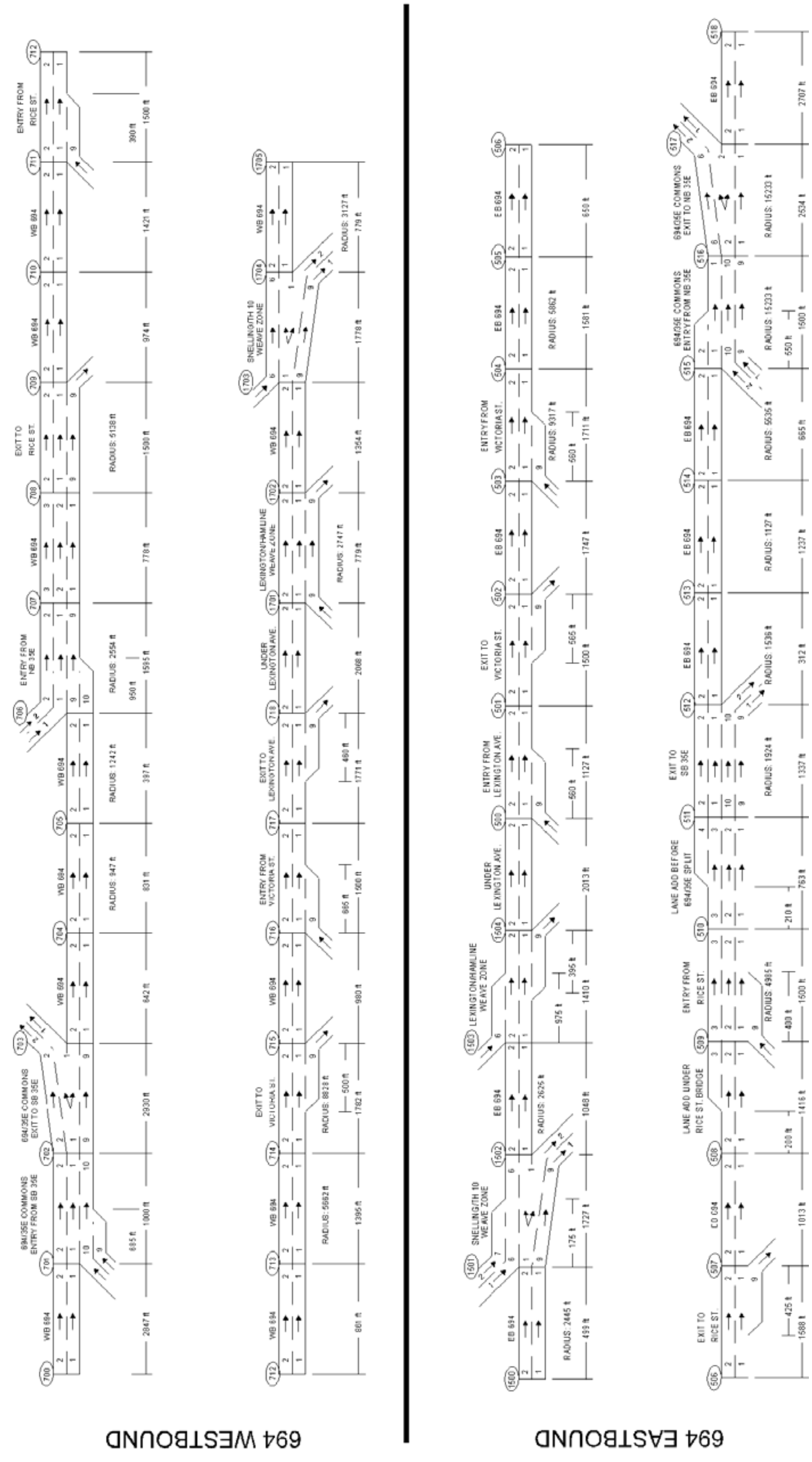


Figure 11 – Lane Schematic

4.2.1 Freeway Node Location Criteria

The freeway and ramp node location criteria in this manual have been developed to assist in the modeling process. These criteria provide a framework and can be modified based on circumstances. However, the criteria are based on replicating Mn/DOT design standards, and they provide practical guidance on developing models from which meaningful results are easier to extract. Generally, all nodes for the freeway model should be located in the center of the roadway and longitudinally using the following criteria:

<u>Mainline Freeway</u>

1. Ramp Junctions

   Nodes are placed at all ramp junctions. **The location of the node should be in the center of the freeway mainline at the painted nose**. Along with coding the location of the freeway mainline node at the ramp junction (painted nose), there needs to be a corresponding length of acceleration or deceleration lane in the model. Mn/DOT's standard single lane ramp designs are taper style ramps; there is a difference in design standards between rural and urban designs.

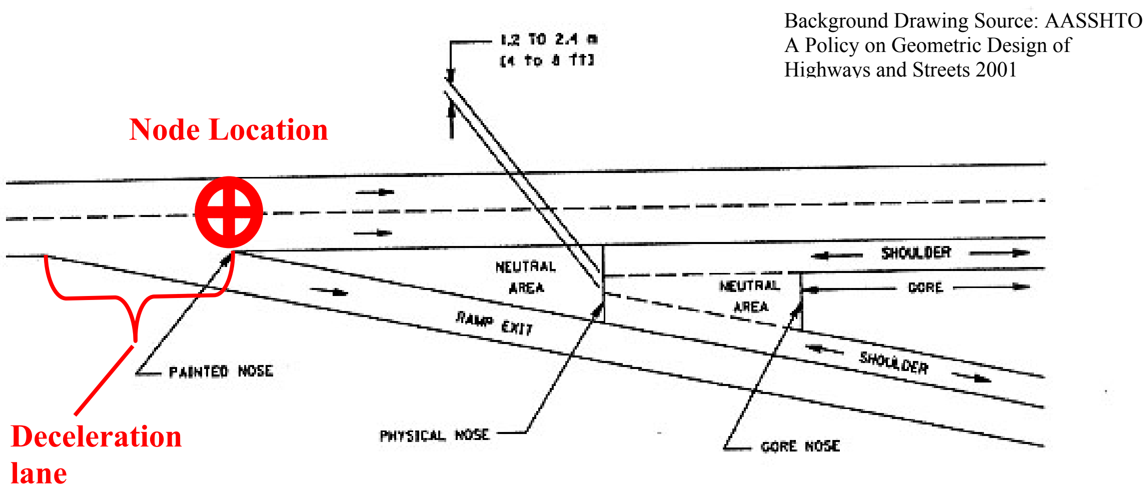


Figure 12 – Ramp Junction Node Location

Within the CORSIM model, it is necessary to include an acceleration or deceleration lane on the mainline to accommodate the transition of vehicles from the mainline to the ramp or to allow entering vehicles to merge onto the mainline. Table 1 shows standard lengths to use in the model on future designs and to provide a frame of reference when estimating acceleration/deceleration lane lengths on an existing freeway. On older freeways or in constrained areas, it is possible that these lengths are less. The distances for the acceleration lanes at on ramps are from 600 to 700 feet; this includes an acceleration lane between 300 to 400 feet plus half of a 600 foot taper. For exit ramps, the deceleration lane begins at the taper.

Table 1
Standard Acceleration and Deceleration Lane Lengths

Type of Ramp	Interchange Type: Urban, Standard Plan Sheet 5-297.106 — Loop	Urban, Standard Plan Sheet 5-297.106 — Standard	Rural, Standard Plan Sheet 5.297.108 — Loop	Rural, Standard Plan Sheet 5.297.108 — Standard
On ramp (acceleration lane)	700 feet	600 feet	700 feet	600 feet
Exit (deceleration lane)	350 feet	320 feet	270 feet	240 feet

2. Ramp Exit and Ramp Entrance Links on the Mainline

   CORSIM results include MOEs that are directly relatable to level of service (LOS) criteria published in the HCM. The ramp chapter and analysis techniques in the HCM were based on studies of mainline freeway segments within 1,500 feet of ramp junctions. Figure 13 below illustrates the 1,500-foot influence area for both on and off ramps. **In order to correlate the CORSIM model to the LOS criteria for ramp junctions, a node should be place 1,500 feet away from the ramp junction.**

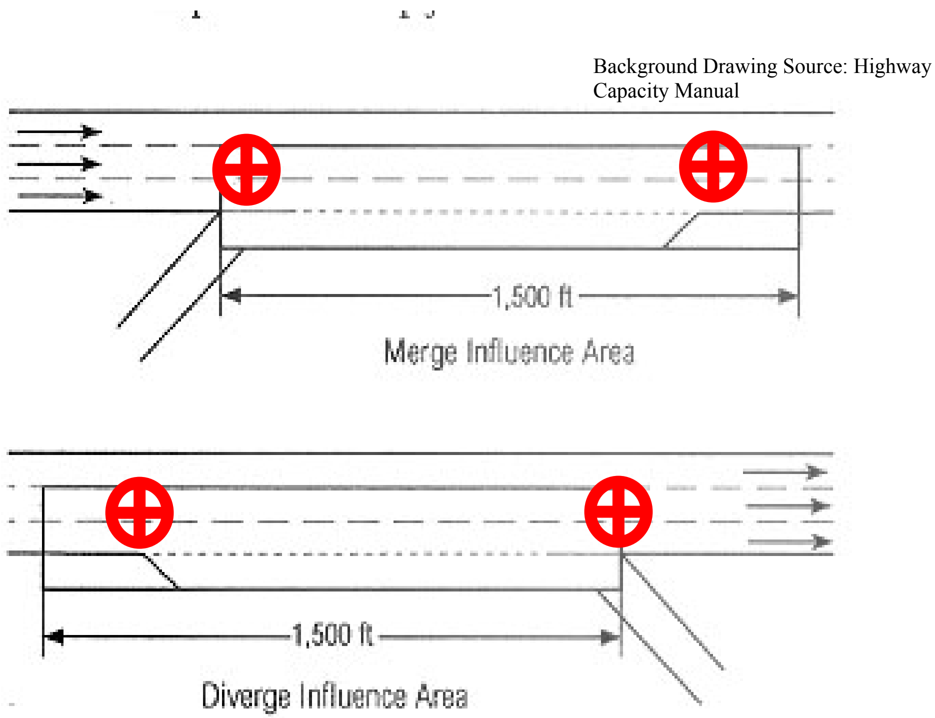


Figure 13 – Node Location Requirements for Ramp Influence Area

3. Points of Curvature

   Nodes should be placed at the beginning and at the end of curves. There are a few reasons for this. The first reason is that the distance around a curve is longer than the straight line distance, accurately reflecting the distance between ramps could be affected if not included properly. Also, the graphics in the animation will be displayed more accurately using the right distance around the curve and the appropriate points of the curve. Secondly, identifying curves is essential to accurately reflect operational characteristics as operating speeds are adversely affected when the radius of curve drops below 2,500 feet. **Curves on freeway alignments need to be identified, especially if the radius of curve is less than 2,500 feet.** Table 2 below summarizes design speed by minimum radius for urban and rural freeways. In summary, curves on mainline freeways less than 2,500 feet have an effect on operations, and these need to be identified on the base map with nodes placed at the beginning and end of curves.

Table 2
Design/Operating Speed by Radius

	Rural Freeways		Urban Freeways	
Design Speed mph	**Limiting Value of Friction factor f**	**Minimum Radius**	**Limiting Value of Friction factor f**	**Minimum Radius**
20	0.17	116	0.3	75
25	0.16	190	0.25	135
30	0.16	273	0.22	215
35	0.15	390	0.2	320
40	0.15	509	0.18	450
45	0.14	677	0.14	677
50	0.14	849	0.14	849
55	0.13	1,042	0.13	1,042
60	0.12	1,348	0.12	1,348
65	0.11	1,637	0.11	1,637
70	0.1	2,083	0.1	2,083
75	0.09	2,546	0.09	2,546

* Source Table 3-2.03A and B, Mn/DOT Road Design Manual

e_{max} = 0.06 ft/ft

4. Grades

Nodes are not usually placed based on grades or profile information; the other mainline criteria will supersede the grade requirement. This is due to the complexity of parabolic curves that are used in transitions between grades; the actual grade on a vertical curve changes at every point along the curve. Also, long straight grades can be added to the model by matching the grade to individual link segments.

The effects that grades have in CORSIM are on the acceleration and deceleration characteristics of heavy trucks. Grades in the field can have other human factors type of effects that cause operational issues; CORSIM will not interpret human factors issues caused by grades. The “calibration” of these conditions is done by other means.

Grades are not a significant factor in most cases in Minnesota because the terrain is mostly flat throughout the state. The desired maximum grade for freeways in Minnesota is 3 percent. The HCM has documented in its methodology that a grade less than 3 percent must be longer than a 0.50 miles to have an effect on truck operations. A grade of 3 percent or greater must be 0.25 miles or longer to have an effect on trucks.

Grades that are significant in HCM Analysis must be coded in CORSIM. Such grades will have an effect on truck performance.

5. Between Interchanges

   Nodes should be spaced an average of 2,000 feet or less throughout the freeway model. Where there are long stretches of basic freeway on tangent sections, multiple nodes should be considered. On long tangent sections, nodes at the beginning of grades should be considered to break up the model into smaller segments. Curvilinear alignments will tend to have enough nodes to break up the freeway into appropriate segments. The reason for this is to facilitate the review of MOEs.

   - If distance is greater than 3,000 feet between ramps – the split should be 1,500 feet downstream of merge and 1,500 feet up stream of diverge (see ramp exit links and ramp entrance link criteria.).
   - 2,500 to 3,000 feet between ramps – the 1,500 feet rule should be applied where possible.
   - Less than 2,500 feet – follow grades and curvature criteria.
   - Less than 1,600 feet between entrance and exit ramps – code as one link.

<u>Ramps</u>

Ramp segments are the links and nodes on the ramp roadway. Because ramps are a transition between facilities, the design includes lower speed curves primary consideration is given to where curves begin. After considering curves, the criteria governing the node locations on ramp links depend on whether it is an exit or entrance ramp or a metered ramp. Another consideration will be if the ramp is a system-to-system ramp (free flow) or if the ramp is a connection to an arterial with at-grade signals. Coding the entire ramp links including the ramp arterial intersections are discussed later in the chapter.

1. Controlling Curve, First Node Away from the Freeway

   Within a standard ramp design, there are provisions for a safe transition of speed. The distance between the physical gore and the painted nose is around 300 feet for both on and off ramps. Figure 14 from the Mn/DOT Road Design Manual illustrates this transition. After this distance, a lower speed curve may be introduced. In the case of loop ramps, this is a very tight curve with a desired minimum radius of 230 feet. On older freeways or locations with other constraints, this radius could be less. **Based on these criteria, the first node for an exit ramp away from the mainline should be at the physical gore.**

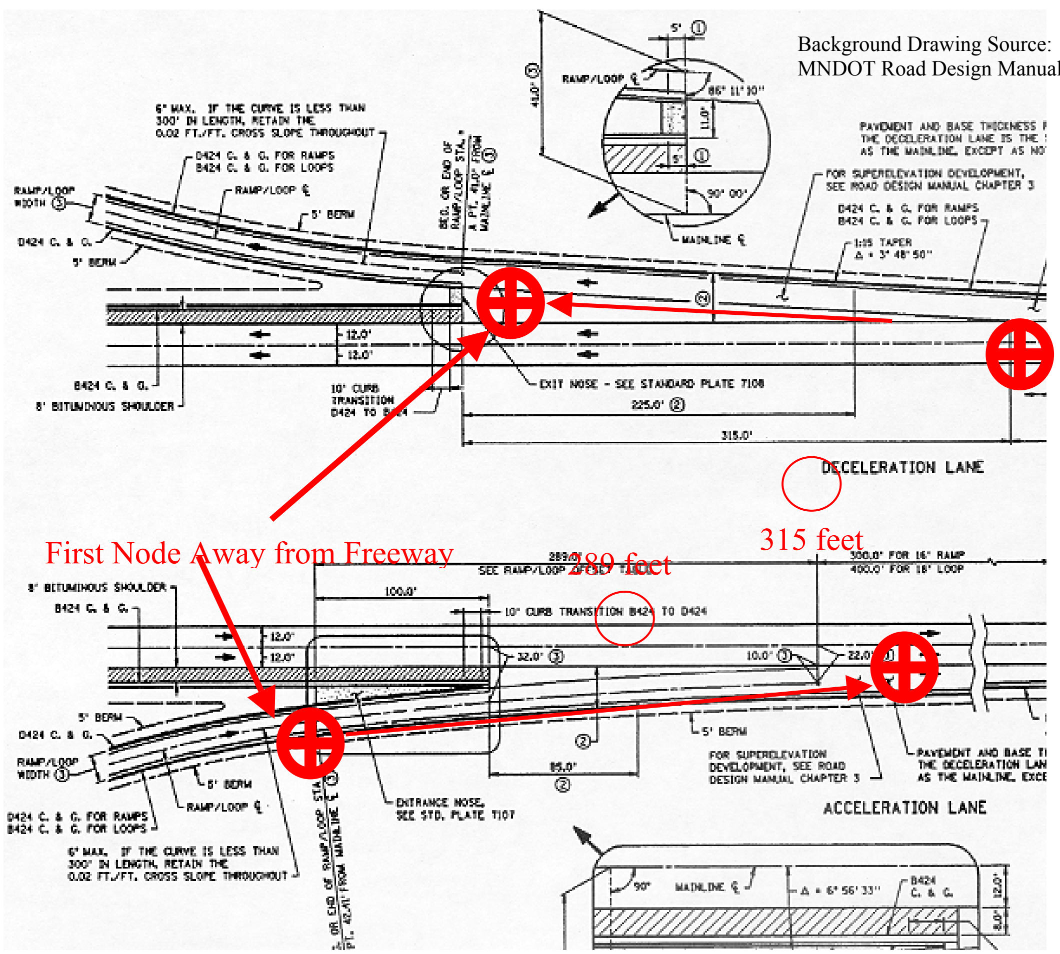


Figure 14 – First Ramp Node Detail

2. Ramp Meters

   A node should be located where the ramp meter is located. During ramp-metered conditions, single lane ramps will operate as two-lane ramps; the signals will alternate green lights releasing one car per green. Mn/DOT's ramp metering strategy is system responsive with ramp metering timing set by zone controls and traffic conditions. As a result of the ramp metering study conducted in 2000, there is a limit to the wait that can occur at a ramp meter. If the traffic backs up to a 4-minute wait or greater, the ramp meter will cycle at the fastest rate, releasing all vehicles on the ramp.

   Coding the ramp meter timing and control in CORSIM is done on a FRESIM ramp node. There are three basic ramp metering control strategy types that can be modeled in CORSIM. The one that should be used for modeling freeway projects in Minnesota is Clock Time Metering. All ramp meters in CORSIM operate as a dual release (i.e., on each green light two cars will leave the meter). Meter rates provided by the TMC will need to be adjusted to reflect two cars departing per green.

   Mn/DOT's ramp metering system is demand responsive. The effort to replicate the demand responsive system and algorithms in CORSIM is not typically necessary for design projects. The traffic management system can provide a report (see below) that will include typical metering rates by ramp. This information is used to code ramp meter rates in CORSIM using the clock-time method.

   <u>Coding ramp meter timing example:</u>

- *Mn/DOT's Ramp Meter Timings.* The timings to use for ramp meter timings are collected from the IRIS system. The IRIS system records the actual ramp meter timings that occurred in the field in 30-second intervals. Below are IRIS Ramp Meter Reports Column Descriptions.

Time:	The start time of that rows 30-second interval.
Cycle Time:	The number of seconds to complete the cycle of red, yellow, green.
Green Count:	The number of greens given in that 30 second time interval.
Greens/Merge:	The ratio of the number of greens given to the merge detector volume.
Queue Occupancy:	The occupancy on the queue detector for the 30 second interval.
Queue Volume:	The volume measured by the queue detector for the 30 second interval.
NOTE:	Any numbers that are followed by an "*" indicate that one of the values that the number was derived from was missing. If a number is replaced by a "?", this means that either all of the values for that total were missing or the

result of the calculation was not a number (i.e., division by zero).

- The raw data will be provided in a comma separated excel file (*.csv). The raw data will then need to be averaged into a constant rate to be used during the simulation period. Below is a portion of a sample IRIS report for the southbound on-ramp at I-494 at Carlson Parkway.

Ramp Meter M494E09 Carlson Pkwy October 10, 2002

Time	Cycle Time	Green Count	Ratio	Queue occupancy	Queue volume
7:15:00	10	3	1.5	9.7	5
7:15:30	10	3	1	7.2	4
7:16:00	10	3	1	10.7	5
7:16:30	10	3	1	5.9	3
7:17:00	10	3	0.8	6.9	3
7:17:30	7.5	4	1.3	5.3	3
7:18:00	10	3	0.8	10.8	4
7:18:30	10	3	1	3.8	2
7:19:00	7.5	4	1.3	9.2	3
7:19:30	10	3	0.8	10.9	5
7:20:00	7.5	4	1.3	7.7	3
7:20:30	10	3	1	3.6	2
7:21:00	10	3	0.8	6.7	3

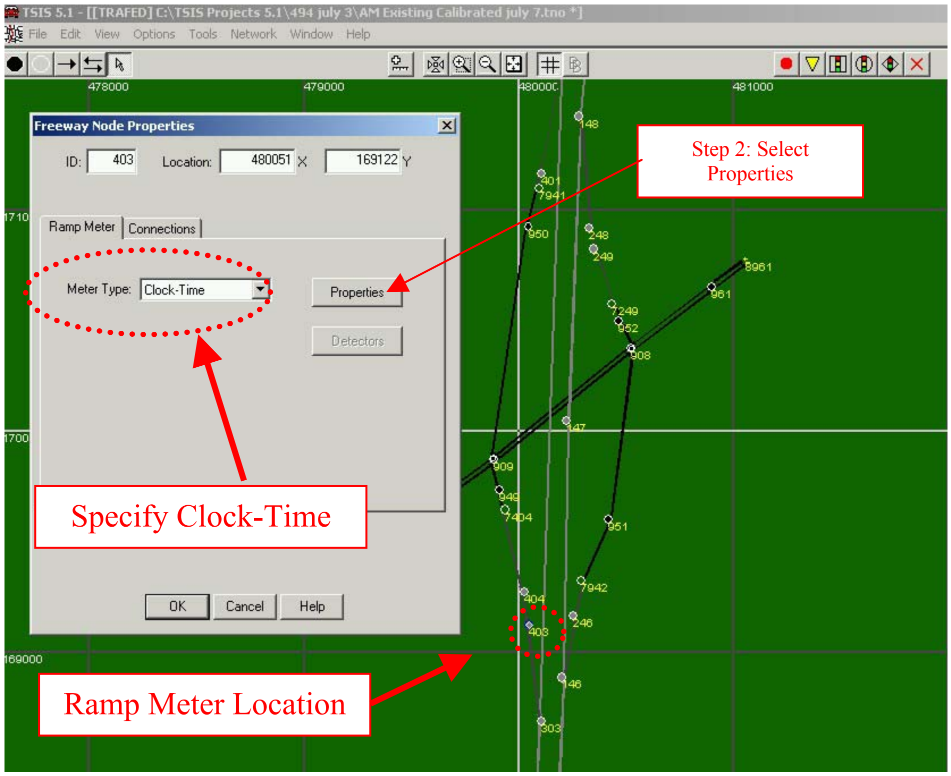
- The cycle time values from the IRIS report are averaged for the duration of the simulation period. All ramp meter timings within the study area should be summarized into a cycle times' table formatted like the I-494 example below.

SP 2785-304 I-494 in Minnetonka, MN Meter Data from October 10, 2002

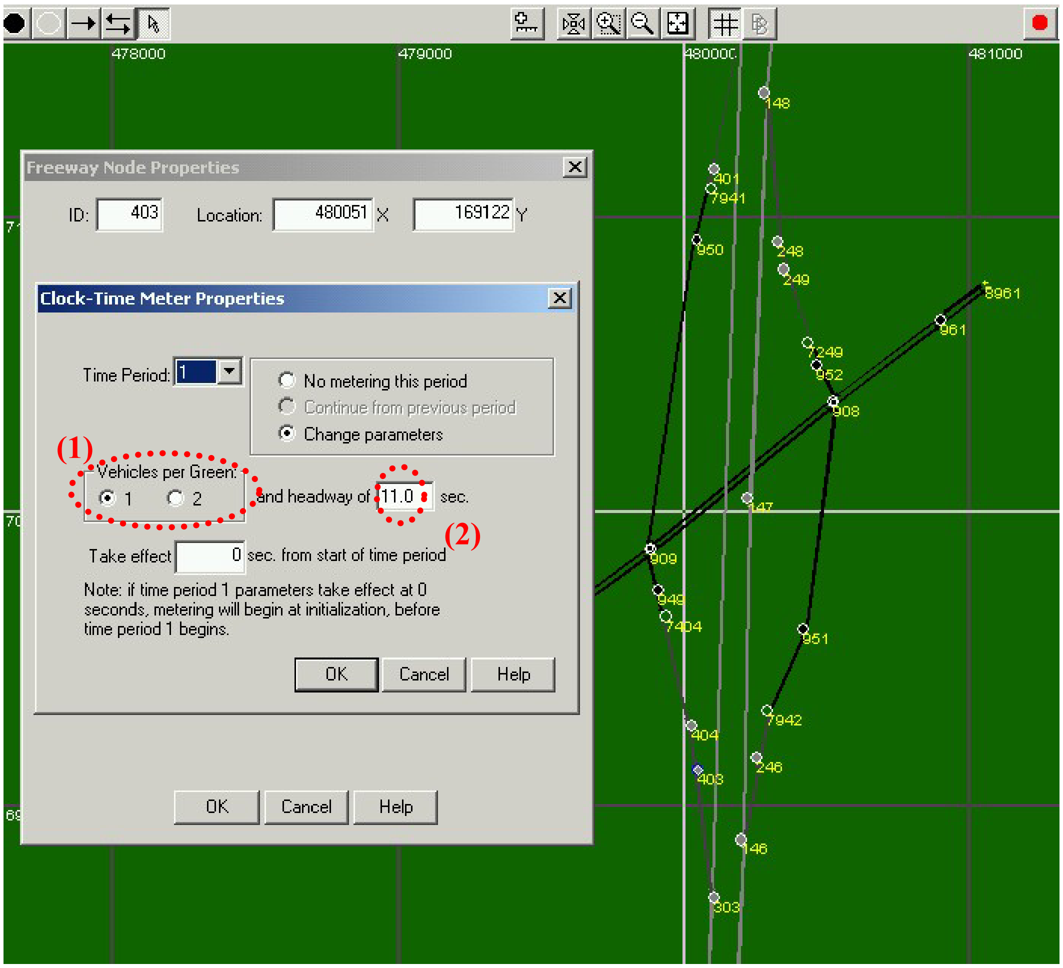
Location	Meter ID	Node	AM Start	AM End	AM Timing (sec/veh)	PM Start	PM End	PM Timing (sec/veh)
Carlson Pkwy.	E09	403	6:15	8:30	11.0	15:30	17:30	6.0
	W65	248	n/a	n/a	0.0	15:05	17:45	5.5
I-394	E10	406	6:15	8:30	7.0	15:10	17:45	3.5
	E11	408	6:10	8:30	4.0	15:10	17:45	6.0
	W63	1617	n/a	n/a	0.0	15:10	17:45	10.0
	W64	244	n/a	n/a	0.0	15:10	17:45	2.0
Minnetonka Blvd.	E13	415	6:15	8:30	10.0	15:30	17:45	10.0
	W61	235	n/a	n/a	0.0	15:10	17:45	8.5
TH 7	E15	419	6:15	8:30	15.0	15:45	17:45	8.0
	E16	421	6:15	8:30	7.5	15:45	17:45	6.5
	W58	228	6:45	8:30	4.5	15:10	17:45	8.0
	W59	230	7:00	8:30	12.0	15:10	17:45	8.5
TH 62	E19	430	6:20	8:30	6.0	15:10	17:45	4.0
	W55	219	6:40	8:30	4.0	15:10	17:45	3.5
Valley View Rd	W53	212	n/a	n/a	0.0	15:30	17:30	4.5

- Coding ramp meter timings into CORSIM can be done using Trafed. The following screen captures illustrate the dialog boxes that appear when a ramp meter is identified for a node.

  Step 1: Specify Clock Time Metering.



Step 2: Select properties and identify one-car per green (1). The entered headway time (2) equals the averaged cycle time from the cycle time's table shown above.



3. System-to-System Ramps

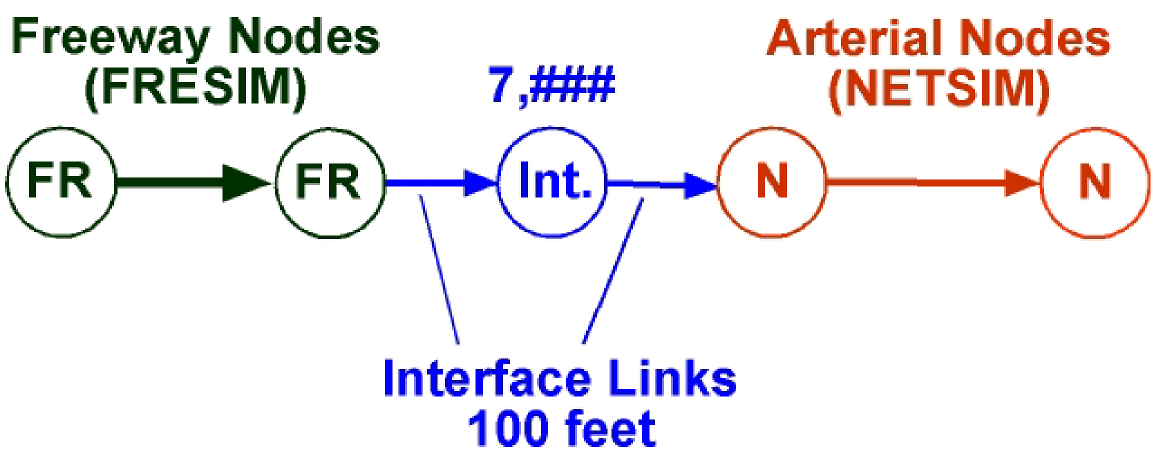
   It is possible in CORSIM to connect freeway-to-freeway directional ramps with a single link connecting the two ramp junctions together. In order to reflect the speed conditions and to facilitate review of results, there should be at least two nodes on these ramps. The node numbering criteria will explain connecting ramps in further detail.

4.2.2 Arterial Node Locations

Arterial node locations are placed based on the location of intersections, transitions from the freeway model, and nodes required to feed the intersections. ***The nodes feeding the approaches to the intersection must be place far enough away so that storage lanes can be accommodated. A rule of the thumb is to place entry exit nodes at the center of adjacent intersections.***

4.2.3 Interfaces Nodes

Interface nodes (7###) are required when the transitioning between a freeway and arterial. These nodes are typically on ramps at service interchanges. ***Generally, at exit ramps, the interface node should be closer to the freeway mainline and at entrance ramps, closer to the arterial.*** The interface links created using interface nodes should be kept as short as possible, 100 feet is a typical distance to use. Statistics on interface links



are not reliable. Figure 15 details how interface links are constructed.

Figure 15 – Interface Link Schematic

4.2.4 Node Numbering Criteria

The purpose of creating a node numbering convention is to create consistency, which allows for easy review by yourself and others. Also combining models becomes an easier process when the likelihood of duplicate node numbers is eliminated. Table 3 below shows the recommended criteria for assigning node numbers. When following this criteria, review of the *.trf file is easier. For instance, if you want to review southbound freeway mainline links, the file is scanned for nodes that are numbered in the 300s.

Table 3
Node Numbering Criteria

Segments	Range		Description
	From	To	
0s	1	99	Miscellaneous
100s	100	199	Northbound Freeway Mainline
200s	200	299	Northbound Freeway Ramps
300s	300	399	Southbound Freeway Mainline
400s	400	499	Southbound Freeway Ramps
500s	500	599	Eastbound Freeway Mainline
600s	600	699	Eastbound Freeway Ramps
700s	700	799	Westbound Freeway Mainline
800s	800	899	Westbound Freeway Ramps
900s	900	999	Arterials

When assigning node numbers, the node value at the beginning of the freeway should be a low value and increased sequentially as you move down the freeway. Allow for gaps in the numbering sequence where there is a potential for new or revised access to the freeway system. Be careful not to be so generous with values that you run out of node numbers before the end of the freeway segment (leaving large gaps between the nodes 100 to 110 to 120 for instance). You will have 99 nodes to work with for one direction of freeway; on average, there will be a node every 1,000 feet. This would create a model 99,000 feet long or 18 miles long. Typical projects are from 3 to 8 miles long.

When assigning node values at entrance ramps, it is useful to "pair" the numbers. For instance, if there is a ramp junction node of 110, the first node on the ramp link should be 210. By "pairing" the last two digits of the ramp junction node and the first node on the ramp, you will have another mechanism for reviewing the input file. Depending on the number of nodes on the ramp link, the pairing sequence may not work. The model will run with any number used as long as it has not been duplicated. The purpose of this "pairing" concept is to make modeling easier, be prepared to move onto the next steps if the model is complicated.

When assigning node numbers on arterials, use the 900 values. The only criterion beyond this that is useful is to assign the lowest numbers to the intersection nodes. So, if you have two intersections in the model, assign the first intersection as 901, the second as 902. By using this numbering sequence for arterials, sorting links in a sequence that facilitates MOEs is a much easier process.

4.2.4.1 Adding to an Existing Model

When adding to an existing model or building a model that exceeds the available numbers within the hundreds criteria, maintain the hundreds criteria by adding a thousands value to it. For example, we want to add to a northbound I-35W model, our existing model stops at node 199. To continue or add to the model, use 1100, 1102, etc. The main reason is to make it clear what is different and to eliminate the possibility of duplicate node numbers. This would also eliminate the need to renumber and recode a completed model.

4.2.5 Typical Link Node Diagram Concepts

There are a number of ways of assigning nodes to a roadway system. The purpose of this manual and the proceeding criteria is to create consistency between modeling efforts and to ensure reproducibility of results. There are a number of interchange areas in the metropolitan area where typical conditions may not be applied. These need to be addressed on a case-by-case basis and may require the modeler to try other methods to determine the best method for modeling the project. Most of the system, however, does fall into a standard arrangement. In these cases, the criteria developed is straightforward. A number of typical link node diagram concepts have been prepared for this manual and are illustrated. This manual can be used as a living document for the modeler. As you encounter unusual modeling areas, make a sketch of the diagram and put into the Mn/DOT web site. If the sample case is very unique or innovative, provide it to Mn/DOT to add to this manual.

Link node concepts illustrated in this chapter:

Diamond Type Interchanges	Diamond interchanges are the most common interchange; however, folded diamonds or partial clover leaf interchanges are quite similar when applying the criteria (see Figures16 and 17).
Single Point Interchanges	Single point interchanges are similar to diamond type interchanges up to the interface links. At the ramp terminal intersection, extra nodes are used to separate the signalized single point from the free flow right turns (see Figure 18).
Freeway Bifurcation	Ramps can only be added to mainline freeway segments in CORSIM. A freeway that splits into two freeways requires special coding. One leg of the freeway split will be coded as a mainline freeway, while the other leg is

coded as a ramp link. Ramp links in CORSIM cannot have other ramp connections; therefore, the freeway split coded as a ramp link needs to be "converted" into a mainline freeway segment. A ramp link is converted into a mainline segment by the use of a "dummy" mainline freeway. Figure 19 illustrates the technique of introducing a dummy mainline freeway.

Collector-Distributor Roads

Collector-distributor (C-D) roads within freeway interchanges are modeled like mini freeways within a freeway. After the freeway exit, the ramp link needs to be converted into a mainline freeway so that the exits and entrances that occur within the C-D road can be modeled. Finally, the C-D road must be converted back into a ramp before it can merge back into the mainline freeway. Figure 20 is an example of a C-D road system for a cloverleaf interchange. This concept can be applied to any C-D road configuration.

On Ramp HOV Bypass Lane

HOV bypass lanes are quite complex when broken down into a link node diagram. The time and effort to model these conditions usually out weighs the benefits. However, if it is necessary to look at a ramp with an HOV bypass lane in greater detail, it is provided in Figure 21.

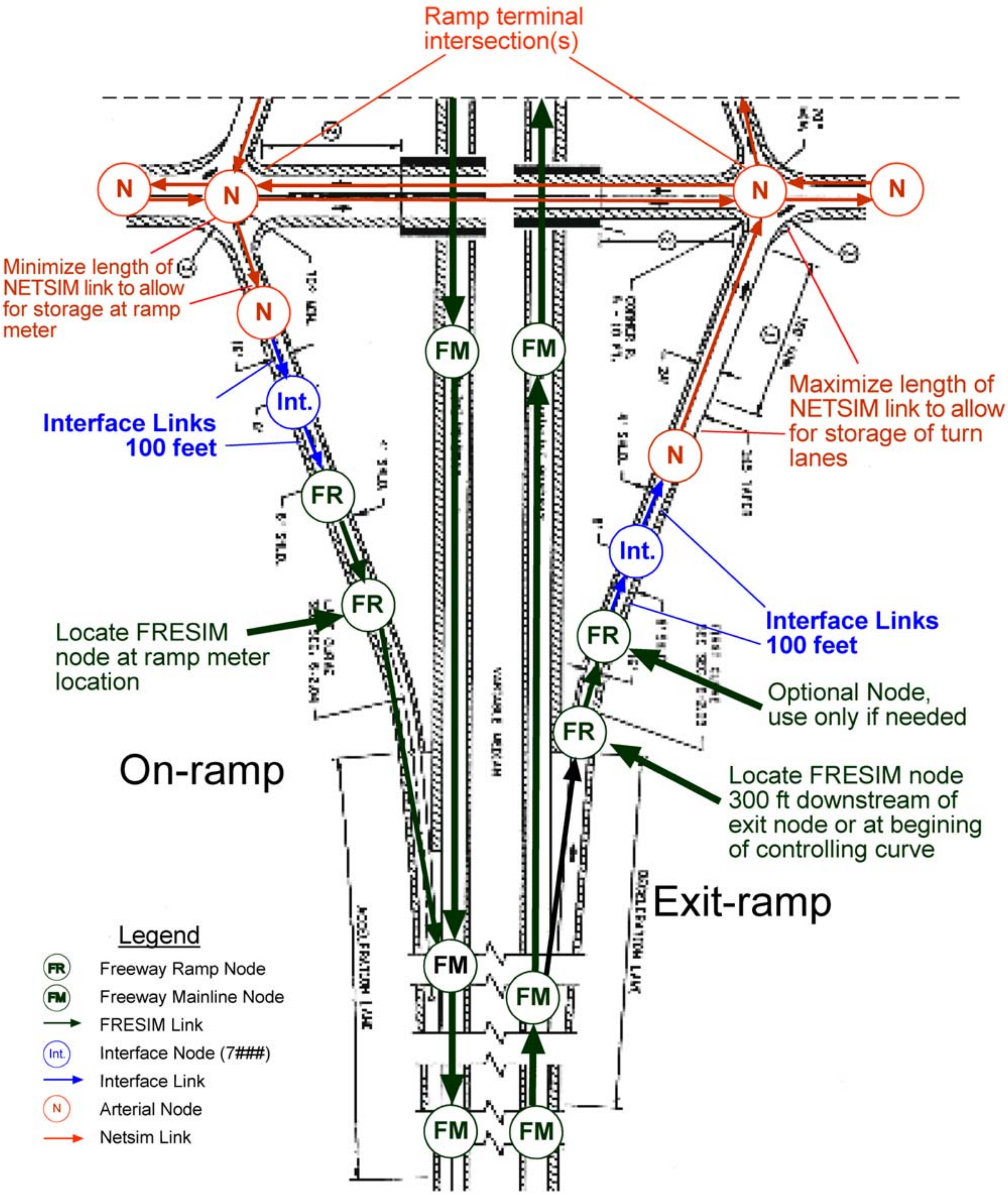


Figure 16 – CORSIM Coding for Standard Diamond Interchange

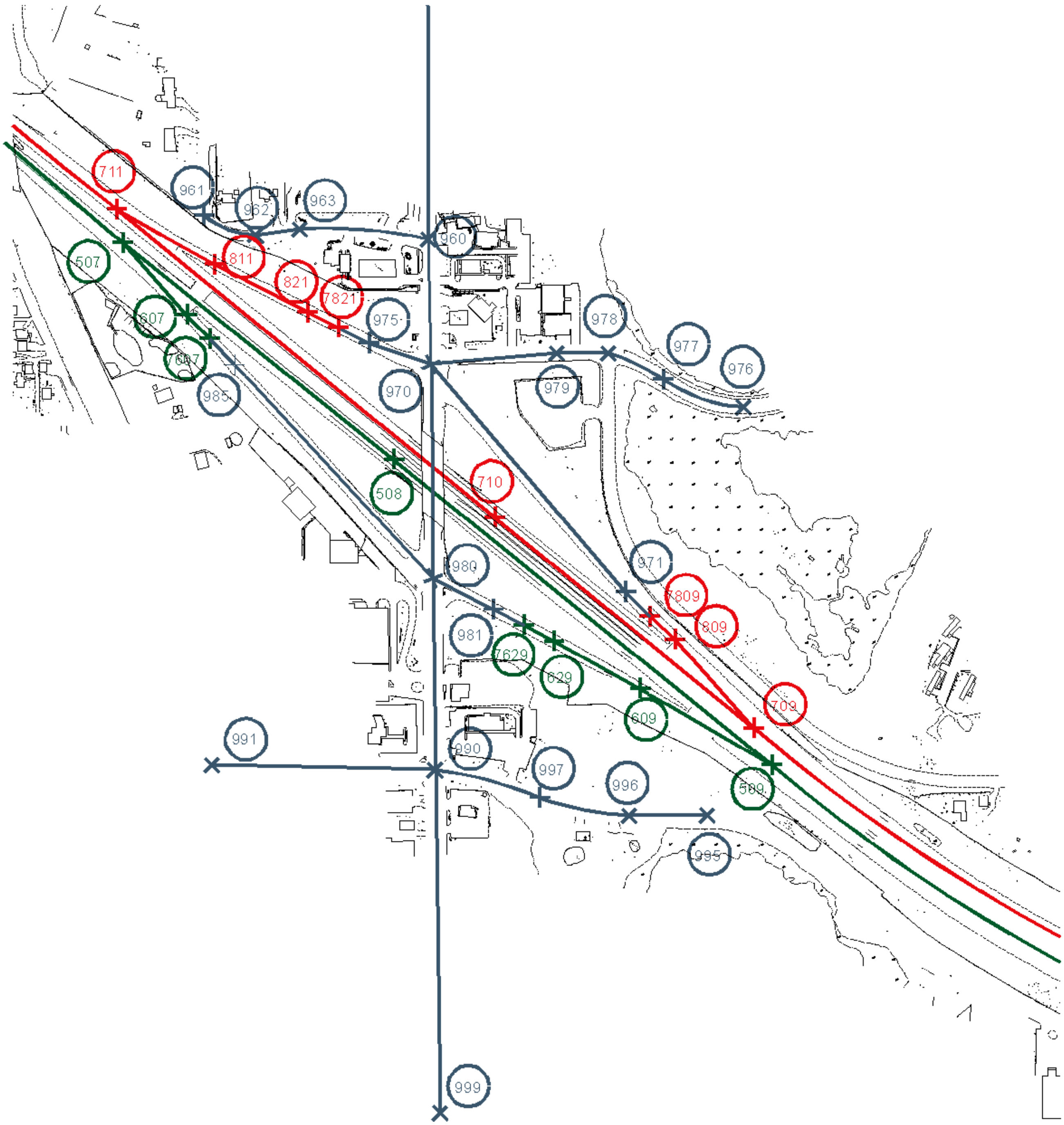


Figure 17 – CORSIM Link Node Diagram Sample: Diamond Interchange

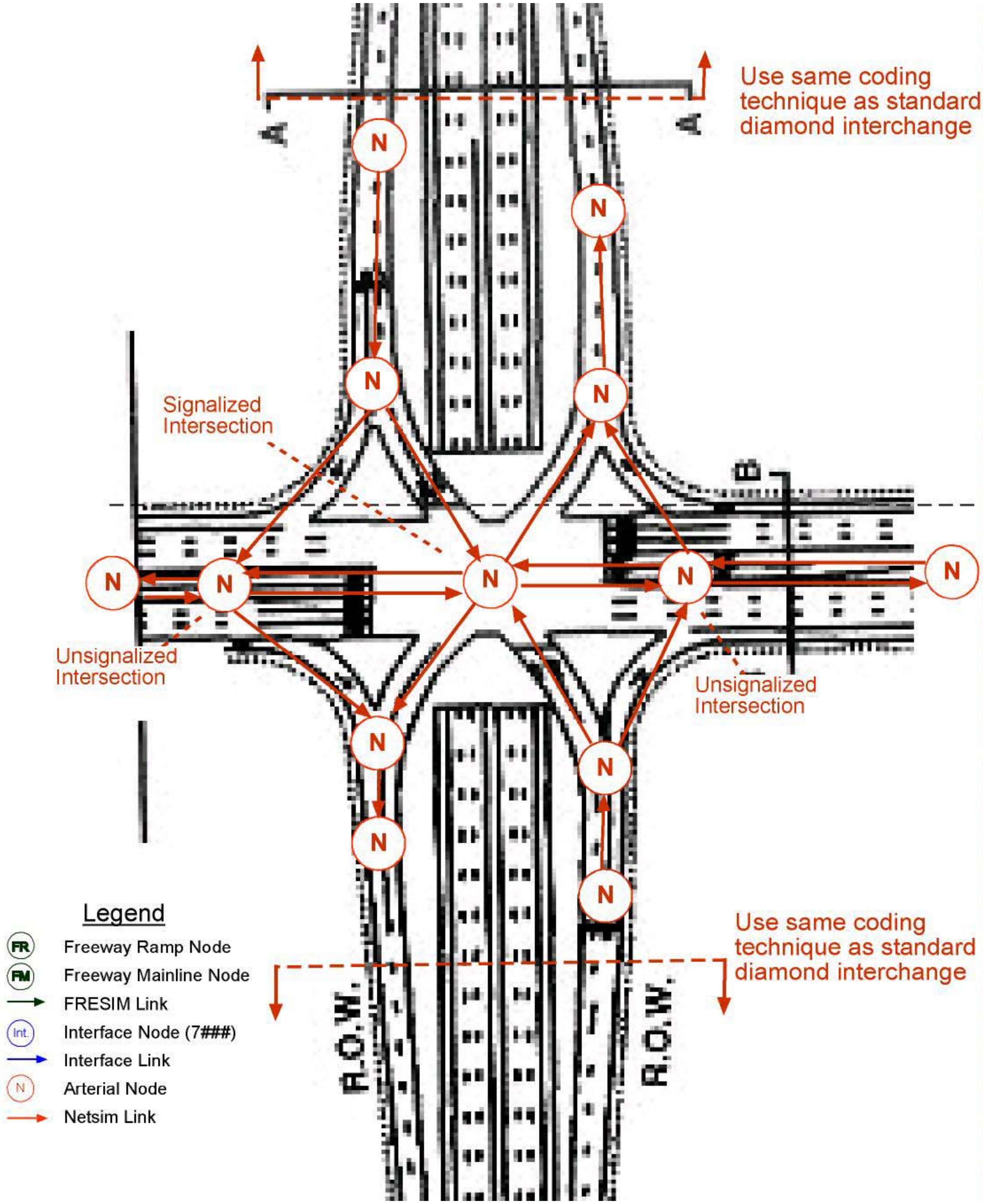


Figure 18 – Single Point Interchange Node Diagram Sample

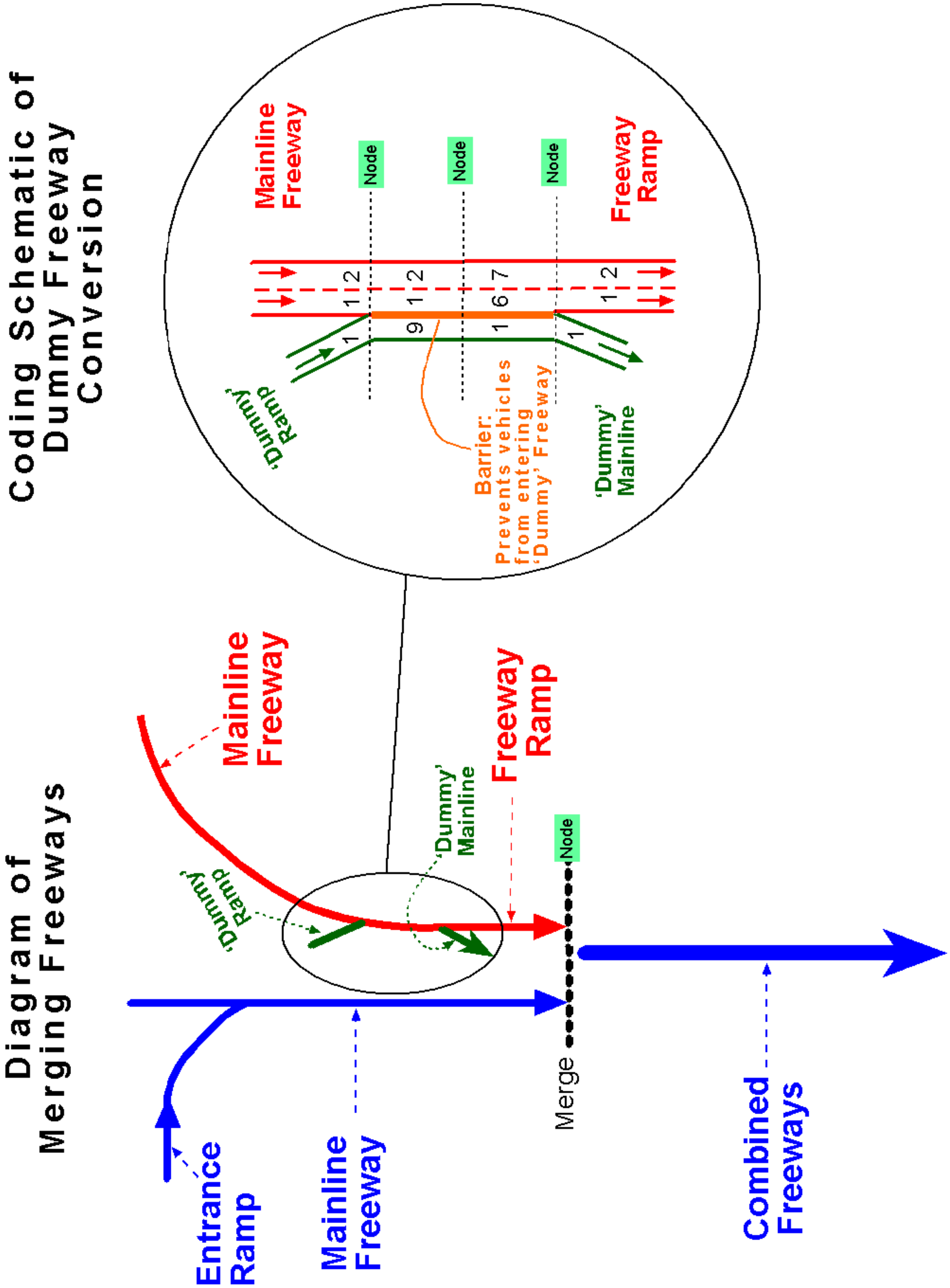


Figure 19 – Freeway Bifurcation Coding Sample

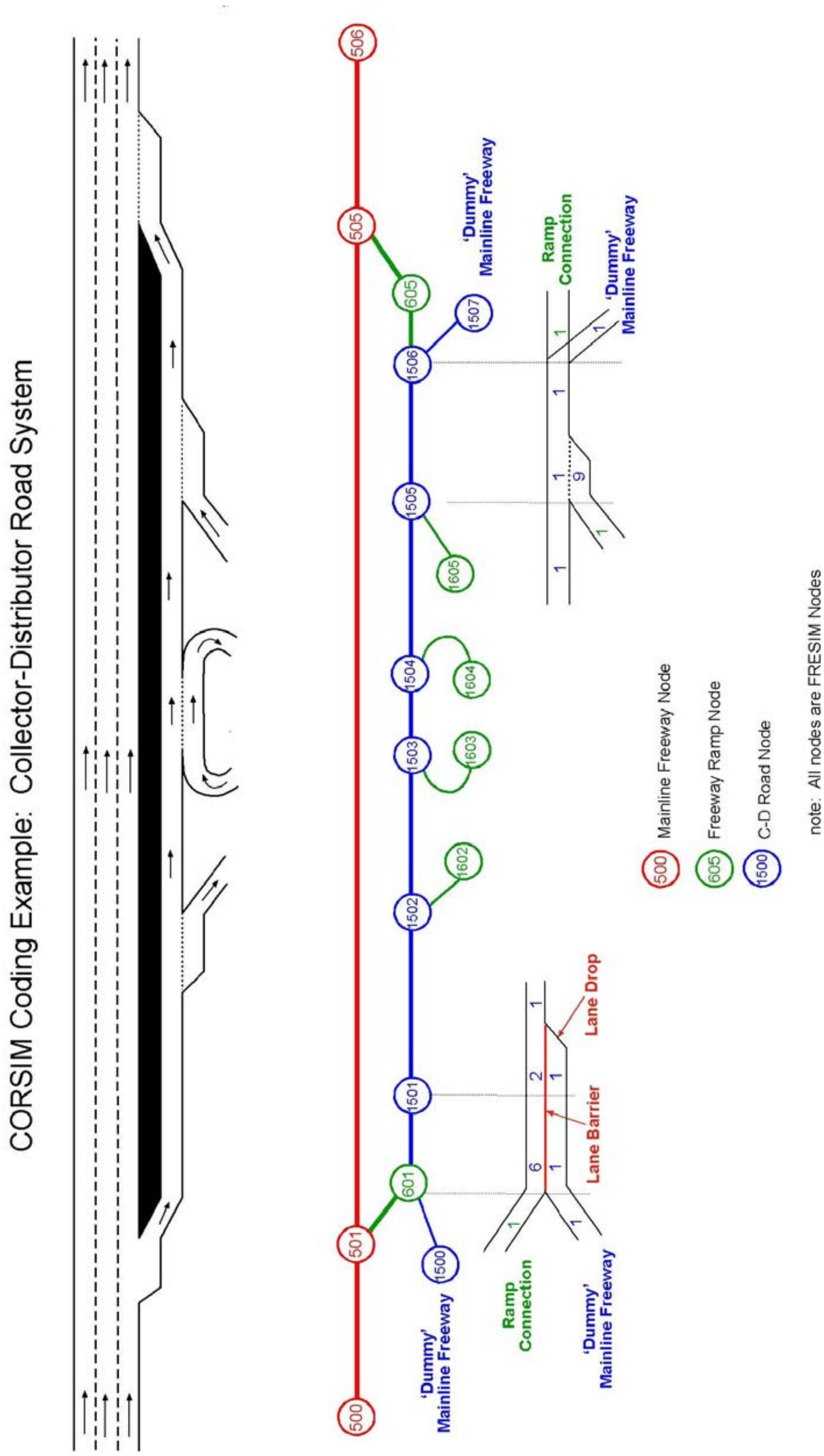


Figure 20 – Collector-Distributor Road System Coding Sample

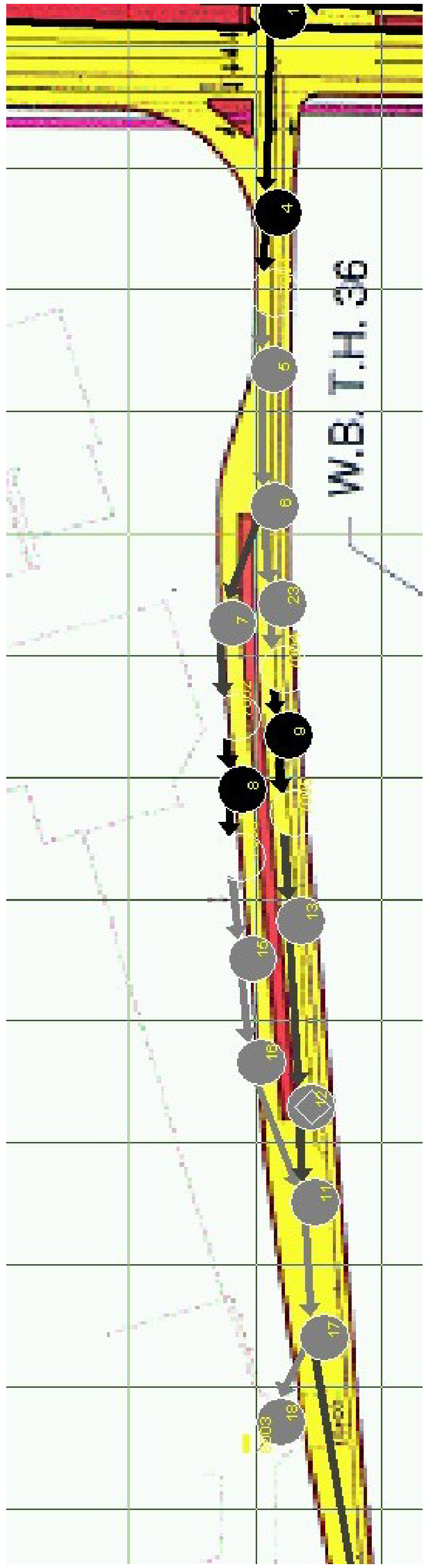


Figure 21 – HOV Bypass Lane at Typical On Ramp Coding Sample

4.2.6 Lane Schematic Development

A lane schematic is a drawing that is prepared with an exaggerated width compared to actual lengths so that lane alignments and lane patterns can easily identified. This schematic aids the modeler in accurately coding CORSIM network. Figure 22 below provides detail lane number diagrams from the TSIS Users Manual. These diagrams provide guidance as to how to develop a lane schematic. Figure 23 is a sample lane schematic from a project. Preparation of the lane schematic should be concurrent with the construction of link node diagram, and both drawings should be reviewed at the same time. If the lane schematic is prepared in an electronic fashion, it can serve as a graphical display of results later on in the modeling process. Features that should be included in the lane schematic include:

- Mainline node numbers
- Distance between nodes
- Length of acceleration and deceleration lanes
- Length of add and drop lanes,
- CORSIM lane assignment numbering scheme
- Radius <2,500 feet
- Grade > 3 degrees
- Label exit and exit ramps
- Label major roadways
- Peak hour volumes (mainline segments and ramps)
- Mainline detector stations

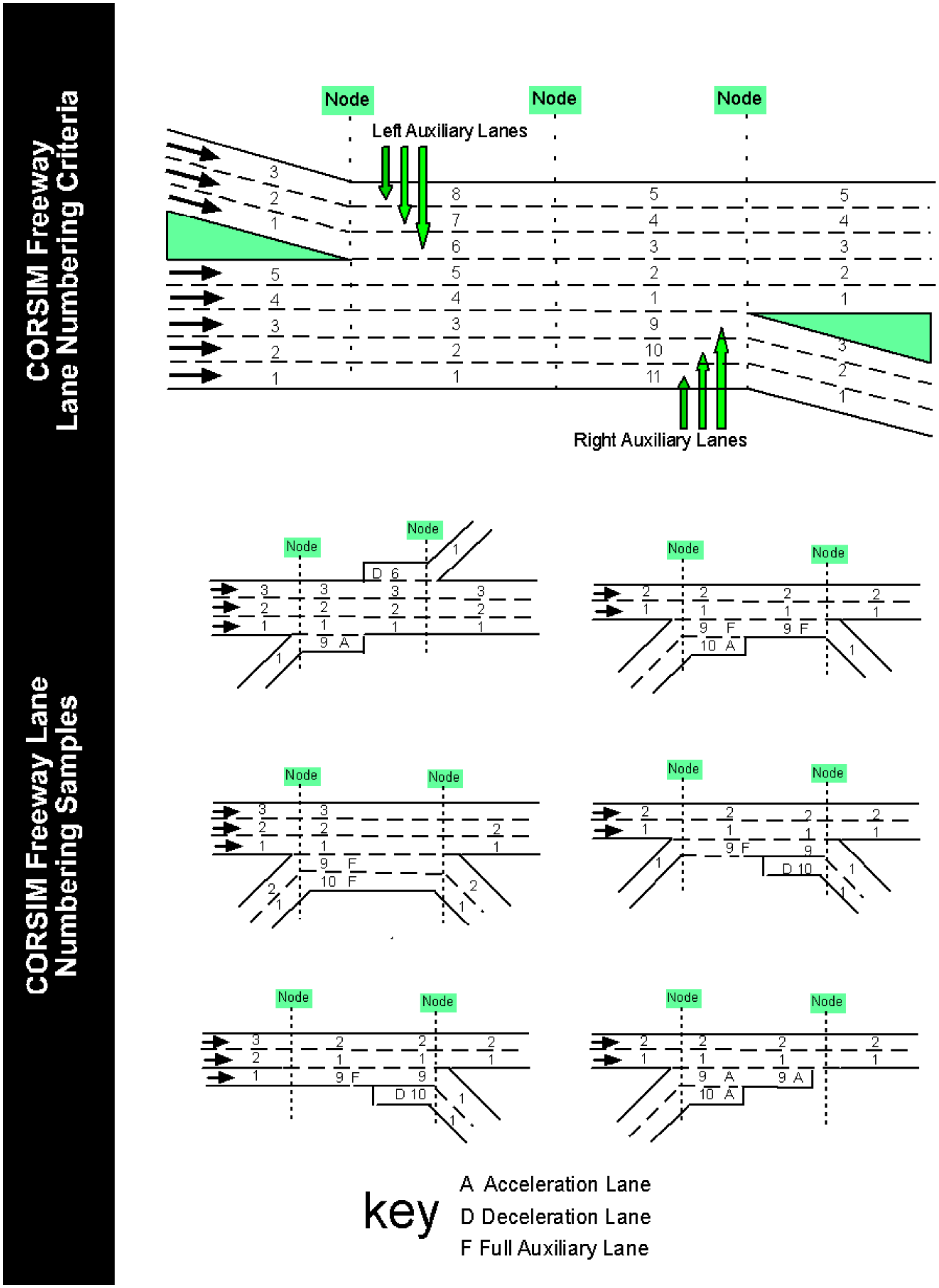


Figure 22 – Lane Schematic Lane Number Criteria

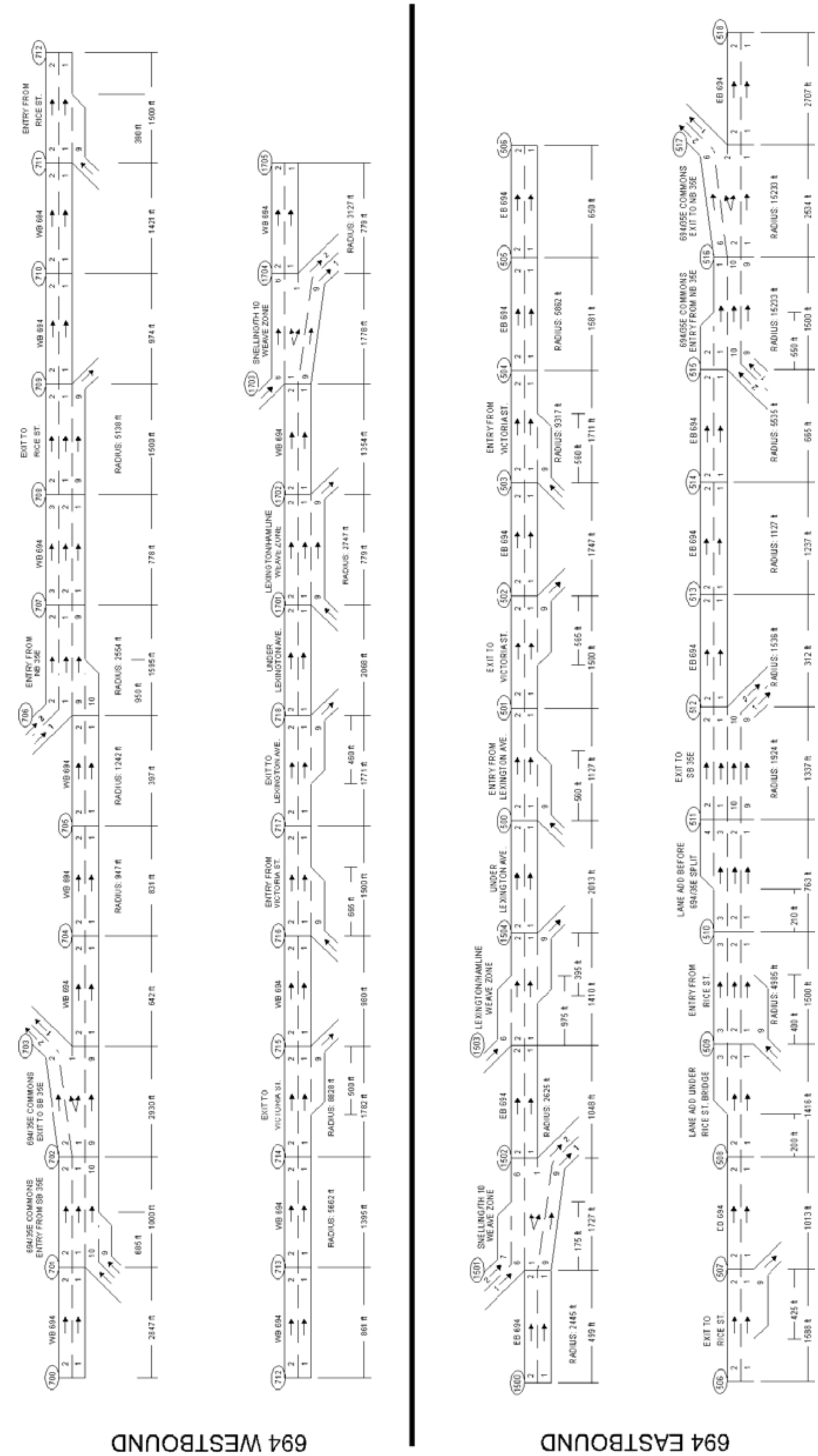


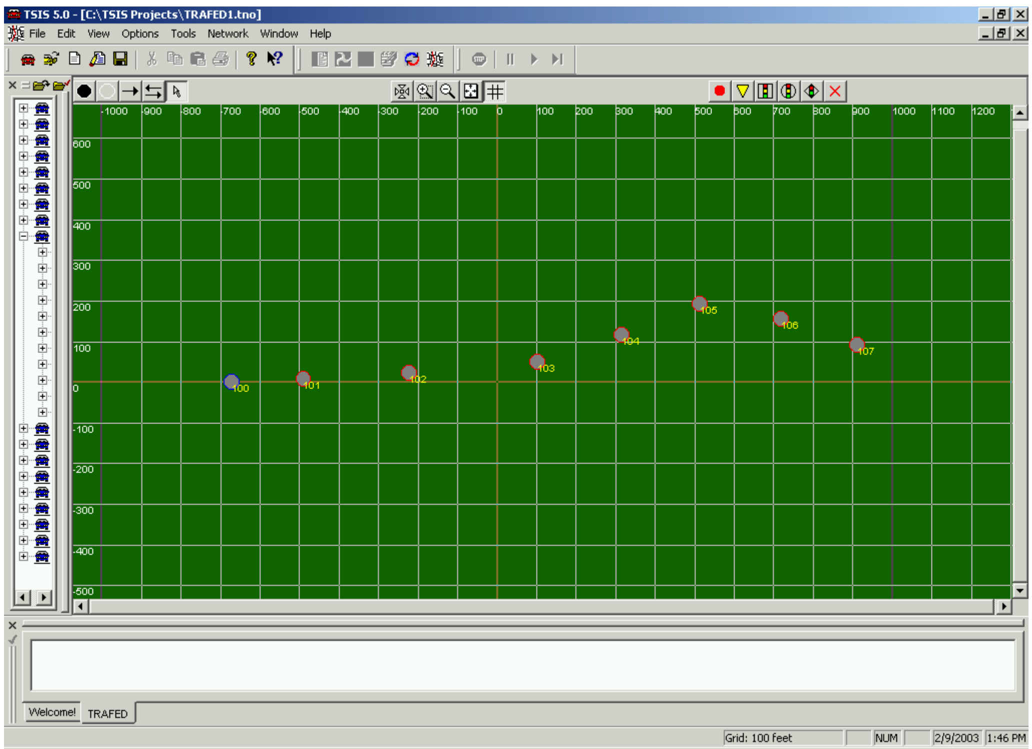
Figure 23 – Lane Schematic Sample

4.3 Part II: Freeway Coding

With the link node diagram, lane schematic, and node coordinates in hand, the actual modeling is a relatively easy process. The initial steps (Steps 2-7) by freeway direction are conducted using TRAFED. TRAFED is the graphical user interface program used for creating CORSIM files. Because the information for coding a model has been prepared to real world coordinates using detailed information, it is not necessary (nor helpful) to use the bitmap background feature in TRAFED.

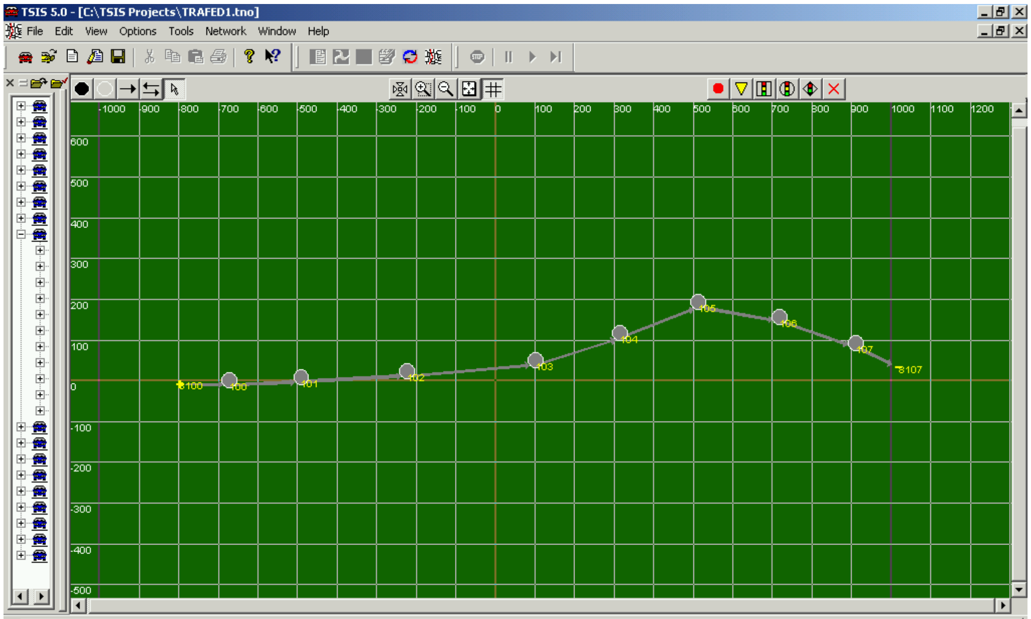
4.3.1 Step 2: Code Freeway Mainline Nodes (Direction 1)

From the link node diagram, the modeler will first place the nodes pertaining to freeway mainline links for one direction of the freeway model in TRAFED.



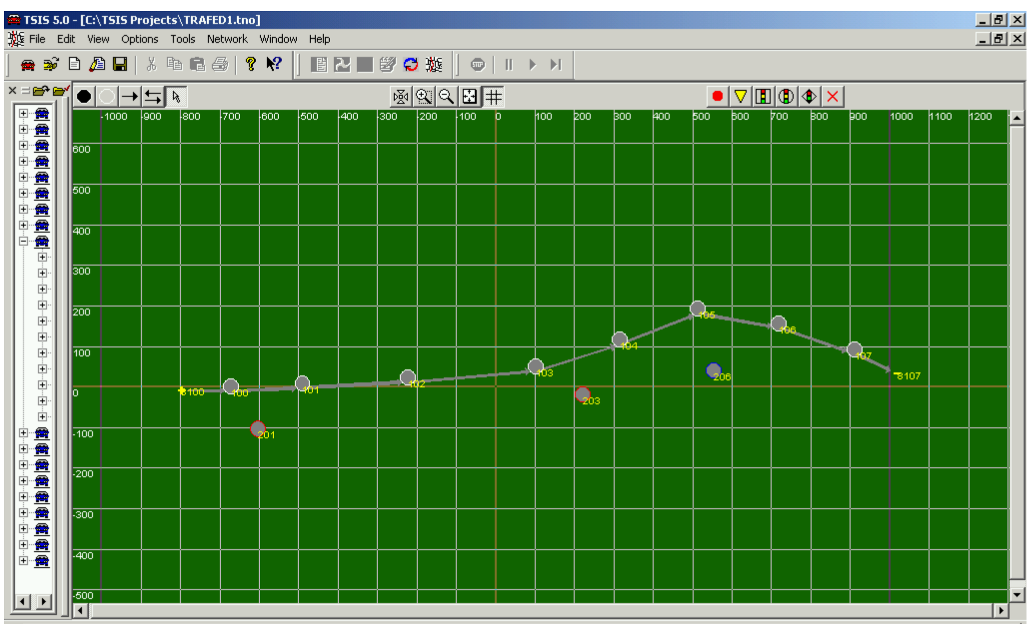
4.3.2 Step 3: Connect Freeway Mainline Nodes (Direction 1)

Beginning where the freeway model starts for direction 1, the modeler will connect each node in sequence in TRAFED.



4.3.3 Step 4: Code Freeway Ramp Nodes (Direction 1)

Similar to Step 2, the modeler will place the freeway ramp nodes required in the freeway model.



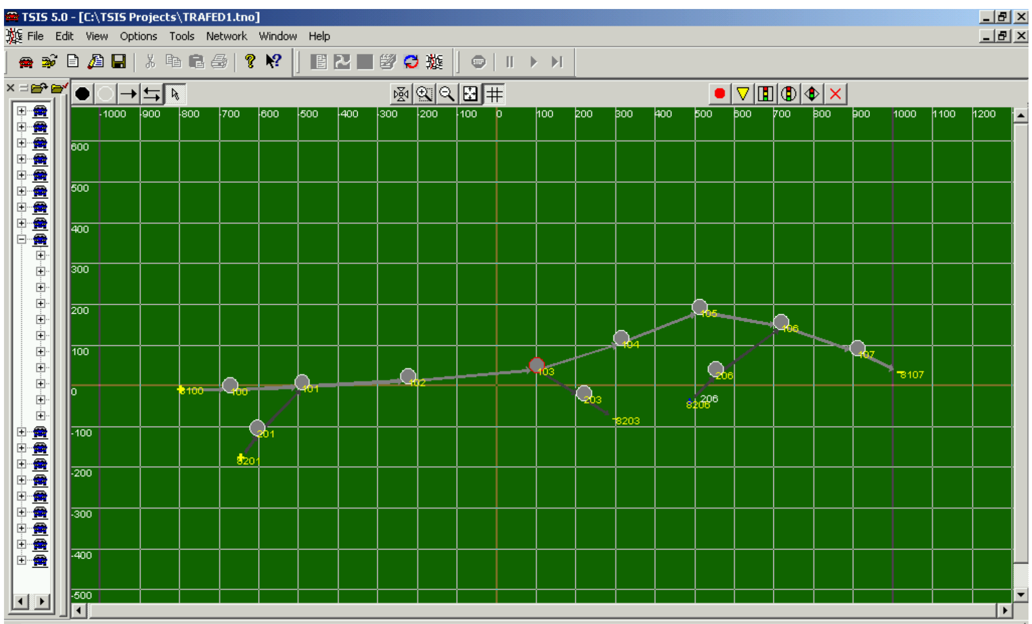
4.3.4 Step 5: Connect Freeway Ramps with Freeway Mainline (Direction 1)

Similar to Step 3, the modeler will connect the ramp nodes to the freeway mainline beginning with the ramps closest to the start of the freeway model. **It is important to understand that the sequence of connecting the nodes can affect the roadway characteristic (whether it is coded as a freeway or ramp).** This condition mostly occurs for modelers at on ramps. You must first connect the on ramp node to the freeway ramp junction node before coding the entry link for the on ramp. If you follow this procedure, the ramp link will be black in the display. If you do not, the ramp link will be light gray in color indicating a FRESIM mainline link. If this does happen, you have two choices:

1) Delete the link and redo the connection in the proper sequence, or

2) Edit the link properties and change from a freeway to ramp designation, remember to change the number of lanes.

Quick Check: Freeway segments and nodes are indicated in gray, while arterial links and nodes are black.

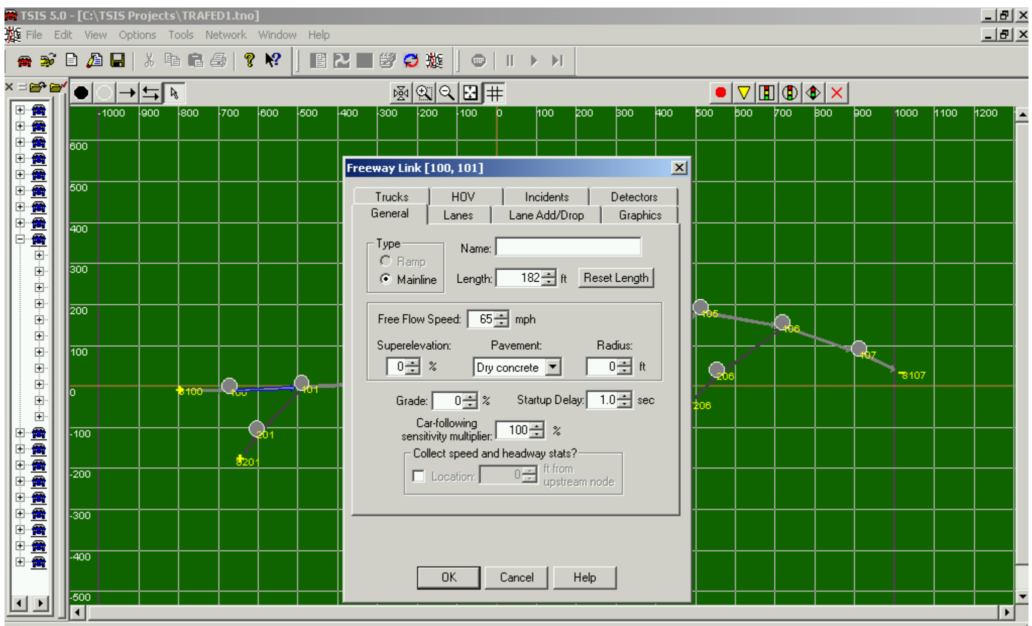


4.3.5 Step 6: Code Physical and Operational Characteristics (Direction 1)

Using the lane schematic developed in Step 1, the modeler will use TRAFED to update the lane geometry and operating characteristics of each link in the model, beginning with the start of the freeway model.

When updating this information in TRAFED, you should use the Lane Schematic Diagram as a reference. The Lane Schematic Diagram will have all the information required to complete this step.

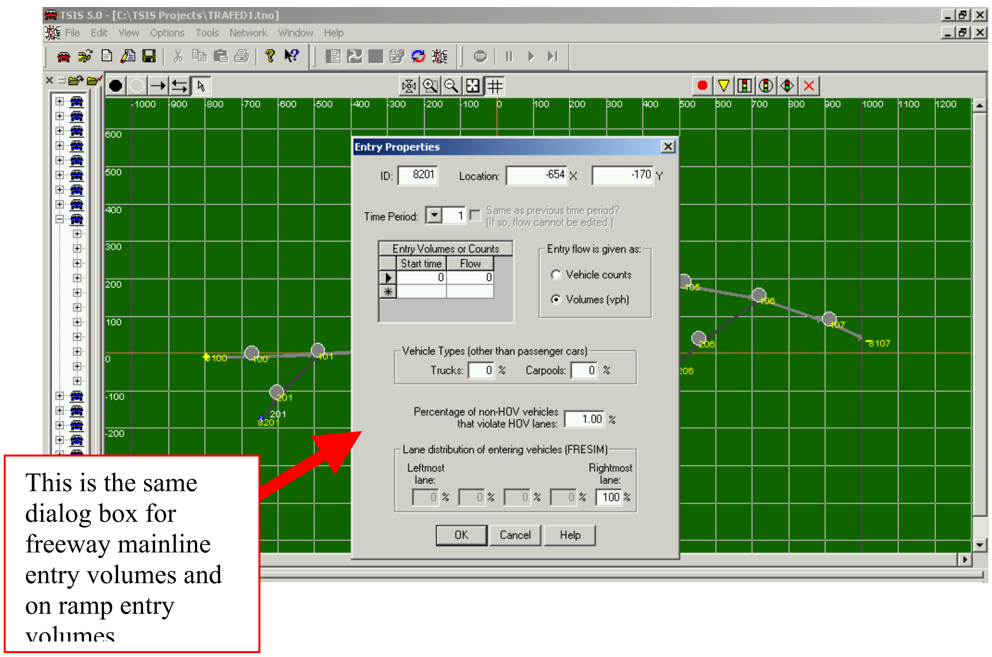
Reminder: When coding Lane Adds or Lane Drops, the designation in the dialog box is not the number of lanes being added or dropped, it is the CORSIM lane number. Only one lane can be added or dropped at a location on a link, up to two lanes can be added or dropped on a link.

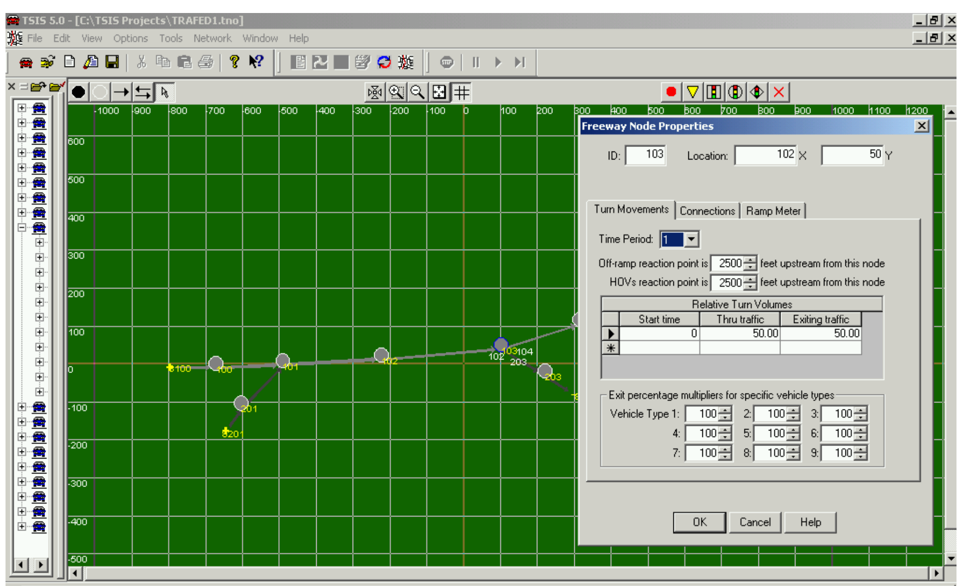


4.3.6 Step 7: Code Peak Hour Traffic Volumes (Direction 1)

Law #2: Do not proceed with modeling without a balanced volume data set of the peak hour.

Coding the peak hour traffic volume allows the creation of a base model that runs and is representative of the condition being modeled. A running model allows for review of the physical inputs in TRAFVU and from the QA/QC form. ***This is a critical point in the model development. Simple mistakes can be found and corrected well before the calibration process. This will reduce and/or eliminate rework***. The base model will be used in later steps to create a start point for multiple time period entries. Volumes at ramps connected to arterials will eventually be replaced with the NETSIM submodel. However, at this stage, on ramp volumes must be entered.





4.3.7 Step 8: Translate and Run Direction 1 of Model

At the end of Step 7, the modeler will have a complete working model of one direction of the freeway submodel. Translate to CORSIM and run the model to verify that it works. Make any edits necessary.

4.3.8 Step 9: Repeat Steps 2-8 for Direction 2 of the Model

Because the link node diagram has been developed for the entire network, it is possible to have another modeler create the model for the opposite direction of the freeway or intersecting freeways. Therefore, a second modeler can start with Part II of the modeling process for the opposite direction. Step 11 will discuss combining the freeway submodels together. If there is only one person working on the model, then Steps 2-8 are conducted in TRAFED using the **SAME** TRAFED file.

4.3.9 Step 10: Repeat Steps 2-8 for Intersecting Freeways

If there are additional freeways included in the model, Steps 2-8 are conducted in the same manner.

4.3.10 Step 11: Combine Freeway Submodels

If there is only one model file for the whole freeway system, then this step is not necessary, and you can proceed to Step 12. Otherwise, the process is as follows.

This step is conducted if a freeway model was prepared by direction in separate files. CORSIM input files are lines of information in an 80 column text format. Each line has a number on the last three columns that is referred to as a record type (RT). Each RT has a different purpose of input. These RTs must be in numerical order by submodel.

All freeway RTs must be grouped together.

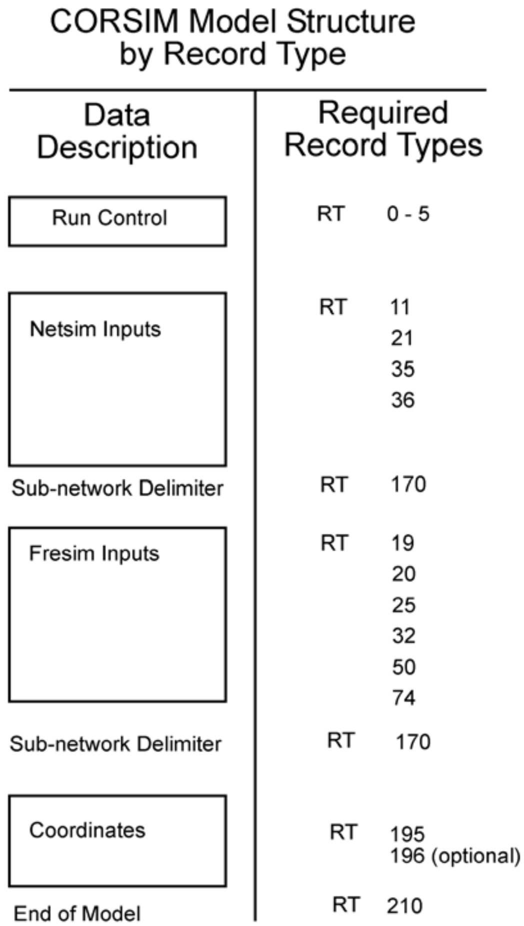


Figure 24 – CORSIM Model Structure by Record Type

Combining different freeway models requires the use of text edit.

- Open all freeway submodel *.trf files in text edit.
- Rename one of the *.trf files. Call it the blank freeway model or a name that identifies it as the complete freeway model.
- Go to the other *.trf file, select all RT 19 information, use the copy command, and return to the main file.
- Place the cursor at the beginning of the RT 19 information. Use the paste command.
- Repeat steps for RT 20, 25, 50, and 195 information.

4.3.11 Step 12: Create QA/QC Worksheet

QA/QC reports are used to verify model inputs and to ensure the organization of the model. The QA/QC reports at this stage are related to the physical geometry and operating characteristics of each link in the model. The modeler needs to create a QA/QC report with the links in a logical order (beginning of freeway to end), and it must include a description of the links (from ramp to ramp, etc.). Figure 25 is a sample QA/QC report, more complete examples of a QA/QC report are available on-line under sample projects.

	Link Description		Link Geometrics												Anticipatory Chg.	
	From	To	Node From	Node To	Receiving Node	Length	Type	No. of lanes	Grade	Super-Elev.	Radius	Speed	Car Following Factor	Warning Sign Distance	Min. Speed to Trigger	Distance to Rx Pt.
EB I-694 Mainline Links	EB I-694		530	531	532	1226	0	2				65	100			
		Exit to Victoria Street	531	532	533	1502	0	2				65	100	2500		
	Exit to Victoria Street		532	533	534	633	0	2				65	100			
		Entrance from Victoria Street	533	534	535	1057	0	2				65	100			
	Entrance from Victoria Street		534	535	538	1500	0	2				65	100		43	1500
			535	538	540	1595	0	2				65	100			
			538	540	542	1069	0	2				65	100			
		Exit to Rice Street	540	542	546	1500	0	2				65	100	2500		
	Exit to Rice Street		542	546	548	1059	0	2				65	100			
		Entrance from Rice Street	546	548	550	1141	0	2				65	100			
	Entrance from Rice Street		548	550	551	1500	0	3				65	100		43	1500
			550	551	552	861	0	3				65	100			
		Exit to SB I-35E	551	552	553	1403	0	2				65	100	2500	43	1500
	Exit to SB I-35E		552	553	554	1541	0	2			1152	65	100			
		Entrance from NB I-35E	553	554	555	648	0	2				65	100			
	Entrance from NB I-35E		554	555	556	400	0	2				65	100		43	1500
			555	556	557	1101	0	4				65	100			
		EB I-694 and NB I-35E Commons	556	557	8557	492	0	3				65	100			
EB I-694 Ramp Links		Victoria Street Exit	532	632	8632	262	1	1				65	100			
	Victoria Street Entrance		634	534	535	415	1	1				65	100			
		Rice Street Exit	542	642	7904	431	1	1				55	100			
	Rice Street Entrance		648	548	550	397	1	1				55	100			
		SB I-35E	552	652	8652	1777	1	2				65	100			
	NB I-35E		654	554	555	554	1	2			1912	65	100			

Figure 25 – Sample QA/QC form

At this point, the modeler has a base freeway model that will be further developed to include the arterial networks (created in Part III) and to include multiple time periods for volumes (created in Part IV). ***Note: The data in the QA/QC form should cross-correlate with the input data within the *.trf file.*** The internal and external QA/QC of the model should be based on what was run. Also, the QA/QC sequence should follow a logic that is easy to follow in a tabular format. If the link order is out of sequence, you cannot follow speed and geometry data that continues from segment to segment.

Review Physical Inputs:
Between link node diagram, lane schematic, and QA/QC form

4.3.12 Step 13: Coding Origin-Destination Information

In order to model weaving conditions in any traffic analysis program or methodology, an O-D matrix, which is an estimate of the number of vehicles from the mainline freeway and entrance ramps destined to the exit ramps and the mainline freeway, is required. The HCM methodology requires that a weave diagram be constructed to help estimate weaving percentages. Figure 26 below is a sample weave diagram that illustrates weaving volumes.

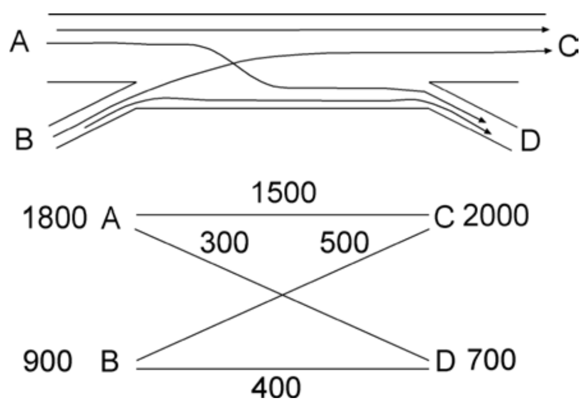


Figure 26 – Weave Volume Illustration

The HCM methodology is only designed to analyze individual weave sections. CORSIM models allow the user to evaluate the effects that different weaving sections have across the entire system. The basic inputs for CORSIM include entering flow rates and exiting percentages. In the absence of user specified O-D percentages, CORSIM will create an estimated O-D. The program also does not come with "built-in" knowledge of the area being modeled. CORSIM will not identify whether a cloverleaf loop ramp weave area is different than any other weave section. In the cloverleaf weave area, the weave percentages are 100 percent – 100 percent of the vehicles entering the freeway are trying to get onto the freeway while 100 percent of the vehicles exiting at the ramp are coming from the freeway mainline.

The cloverleaf interchange area is the most dramatic case of modeling weave section that CORSIM will not interpret for the modeler. If the modeler does not manually create O-D inputs for the model, they will not end up with a valid model, resulting in large numbers of vehicles entering at the on loop and exiting at the off loop. It is possible to model partial O-Ds in CORSIM; however, for consistency and a clear understanding of what the model is doing, O-Ds should be coded for all freeway mainlines in the model. The most efficient way to calculate O-Ds for the model inputs is to create an O-D matrix. The following discussion explains how to set up an O-D matrix that provides the input for CORSIM.

Note: By not manually entering an O-D matrix, you have made an assumption on weaving. You have assumed that the O-D pattern internally calculated by CORSIM reflects reality. CORSIM cannot distinguish between a closely spaced weave section

and a cloverleaf interchange. The unrealistic movements described in the example would occur in the model.

4.3.12.1 Creating an O-D Matrix

An O-D matrix is a table that organizes entering and exit volumes. The preferred way to organize this information is to list entering volumes in rows on the left and exiting volumes in columns across the top. The entrance and exit locations should also be in sequence. The O-D table is populated by estimating the number of vehicles originating from a particular entrance location that exit at a particular downstream destination. The volumes from each entrance and at each exit are divided against the total volume to determine the total percentage. Figure 27 below is a sample O-D matrix. The O-D matrix table provides a back check of balanced traffic volumes. If the sum of the entries and the exits do not equal each other, then there is a problem in the O-D calculations or in the source traffic volumes.

I-94 Eastbound (PM)				Exit Locations												
	Entry Location Detector			SB I-35W 812			NB I-35W 818			SB TH 55 822			end/exit 826			
				95			2191			2605			465			
Name	Station	Node #	Volume	Volume	Vol %	New Volume	Volume	Vol %	New Volume	Volume	Vol %	New Volume	Volume	Vol %	New Volume	
I-94 Eastbound	108	804	1521	420	0.28	1101	301	0.20	800	210	0.14	590	590	0.39		101%
Hennepin/Lyndale	241/3150/315	806	436	121	0.28	315	86	0.20	229	60	0.14	169	169	0.39		101%
5th Ave	2604	819	138	0	0.00	138.23	0	0.00	138	36	0.26	102	102	0.74		100%
NB I-35W	2609	825	281	0	0.00	281.11	0	0.00	281	0	0.00	281	281	1.00		100%
			2377	541			387			307			1142			2377
				541			387			306			1142			2376

Figure 27 – Sample Origin-Destination Calculation Worksheet

In brief, the steps are as follows:

1. Identify by ramp name
   - All entrances
   - All exits
2. Identify corresponding node according to the following criteria:
   - Enter volumes for each entry and exit including the end of the freeway.
   - Starting from the beginning, calculate by entering the number of vehicles system by each destination.
   - Calculate the percentages of vehicles entering at the origin node and exiting at the destination node.
   - Convert information in the O-D matrix table into RT 74 input. This includes every entry and exit pair and the corresponding percentage of traffic.

4.3.12.2 Calculating O-D Percentages

Calculating O-D percentages can be as precise as actual weaving based on a license plate O-D study or estimated based a variety of methods. Methods for estimating O-D include assigning obvious weave patterns, such as cloverleaf interchanges, and then estimating the remaining O-D percentages based on a uniform distribution. Another method is to use a select link analysis at each entrance to determine percentages from a regional travel demand model to identify the freeway O-D.

The potential exists for rounding errors in the calculated O-D pattern. There are two potential problems. The first is, if the rounded values for entry location exceed 100 percent, this will result in a fatal error, and the model will not run. The best way to deal with this situation is to leave the last O-D pair out of the model. CORSIM will internally calculate any O-D pairs that are not included in RT 74. The second issue is at low volume exit ramps. If the O-D percentage for multiple entries end up rounding down, then there may be a shortfall in traffic. In this case, you may want to force the equation to round up to account for the exiting traffic.

Regardless of how the O-D matrix is derived, it will be based on more intelligence and engineering judgment than the CORSIM created O-D. If the matrix to model input process is automated, then it is possible to test the model with different O-D patterns. This is especially useful when conducting sensitivity tests on future designs.

4.4 Part III: Base Arterial Model Development Steps

The arterial base model is primarily set up using Synchro (could be TEAPAC as well). The process for modeling intersections includes coding geometrics, signal timings, etc. Synchro is a more efficient tool for modeling intersections than TRAFED. In addition, Synchro is useful when alternatives need to be tested and intersections need to be retimed. Synchro is an optimization tool that should be used in developing timing and improvements. Another person independent of the freeway model can conduct this step, but this should only be started after the link node diagram is created.

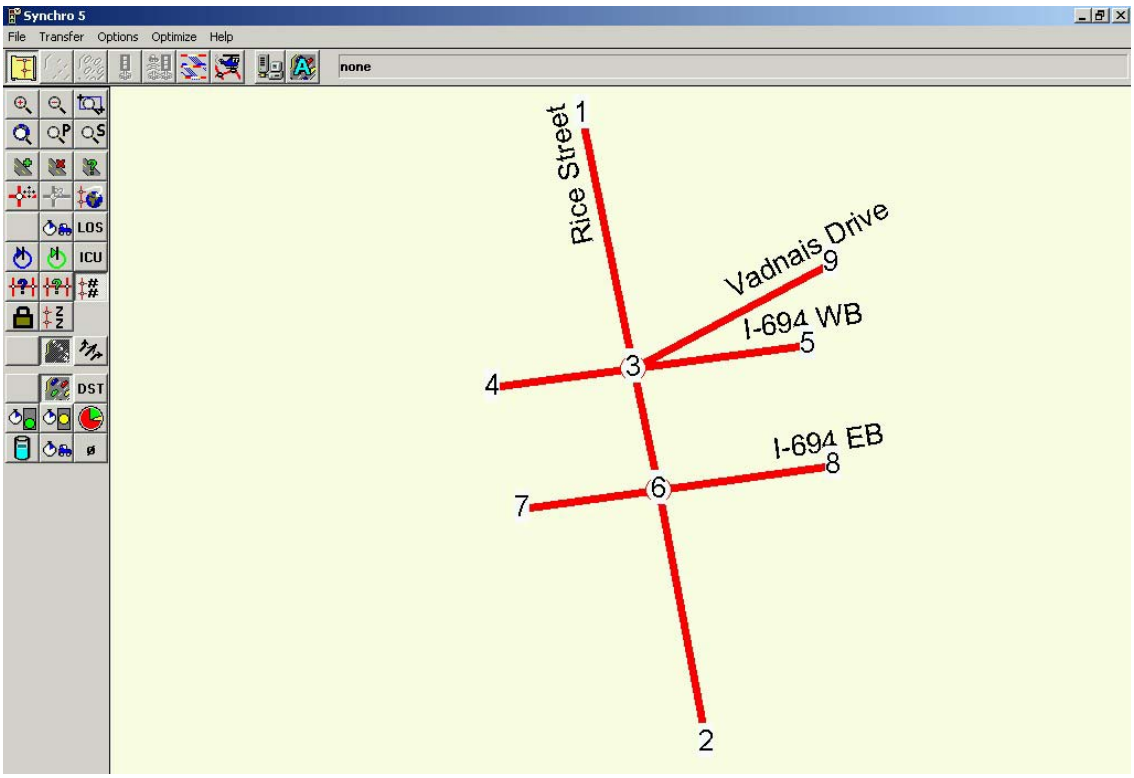
Each intersection in the arterial base model is created in Synchro using the same coordinates and node numbers from the main link node diagram. The inputs for each intersection can be verified using SimTraffic. After the arterial base models are created, the "Transfer CORSIM Analysis" feature in Synchro is used to create the NETSIM submodel. The submodel can be run in CORSIM and viewed in TRAFVU to ensure that the intersections have been coded properly. After the arterial submodel has been verified, the modeler is ready for Part IV, Combining Freeway and Arterial Models.

Details of signal timing and the use of Synchro can be found in the Signal Timing and Coordination Manual located on Mn/DOT's web site at:

http://www.dot.state.mn.us/trafficeng/

4.4.1 Step 1: Create a Synchro Model of the Ramp Terminal Intersections

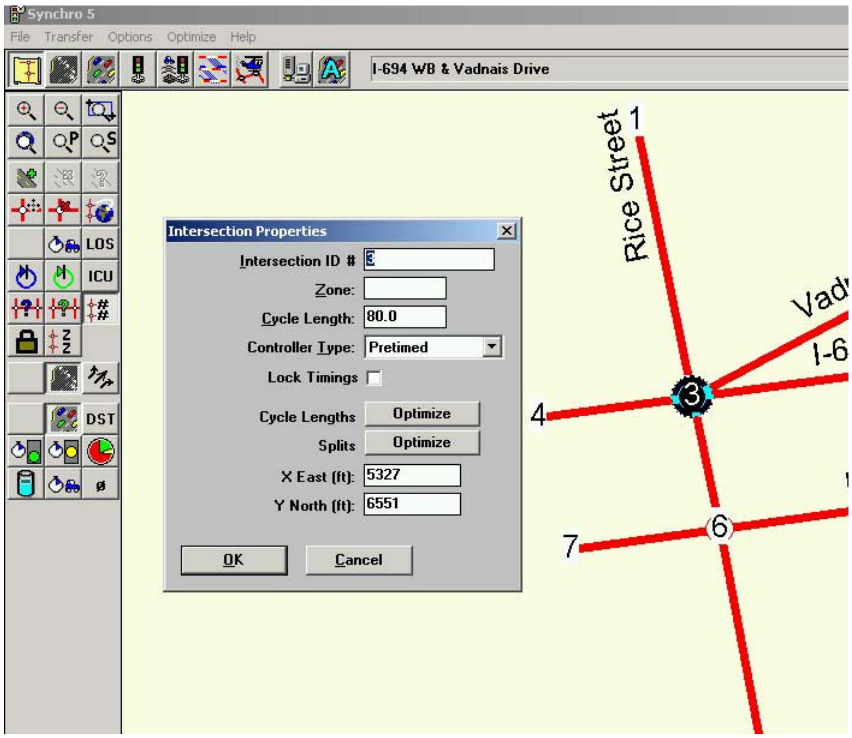
There should be one file for all interchanges in the CORSIM model. The steps following this step will involve updating the Synchro node numbers to match the overall link node diagram and to update the node coordinates. Initially, you are using Synchro to build a basic model that has the correct orientation; intersections spacing should be approximated. The node that leads into and away from the intersections is automatically created by Synchro. You must locate this node using the coordinate information from the main link node diagram.



Step 2: Change Node Numbers and Coordinates

Change node numbers and coordinates to correspond with link node diagram. Transform map to relevant coordinate system.

Change node numbers in the Synchro map view to match the arterial node numbers from the link node diagram. Do not include the interface nodes (7,###) or the entry/exit nodes (8,###) nodes in the Synchro model, only construct the 9## nodes. Synchro will automatically create the entry/exit nodes, and the 7,### nodes will be created in Part IV.



Changing the node coordinates in the Synchro model to match the real-world coordinates from the link node diagram is done using the Uniform Traffic Data Format (UTDF) feature in Synchro. The procedure is outlined below.

- In the map view, either go to the transfer menu and select Data Access or hit CTRL-D, to open the Database Access Menu.
- In the UTDF database select the LAYOUT tab.
- In the LAYOUT menu, use the SELECT file button to ensure that the LAYOUT.DAT file is located in the working directory.
- Using the cursor, select the WRITE button and left click the mouse. You have now created a text file that includes the node numbers and X and Y coordinates. Figure 28 shows what this file looks like in Notepad.

Layout Data

INTID	TYPE	X	Y	NID	SID	EID	WID	NEID
1	1	5057	7871		3			
2	1	5707	4601	6				
3	0	5327	6551	1	6	5	4	9
4	1	4592	6453			3		
5	1	6236	6671				3	
6	0	5459	5919	3	2	8	7	
7	1	4747	5820			6		
8	1	6368	6045				6	
9	1	6357	7097				3	

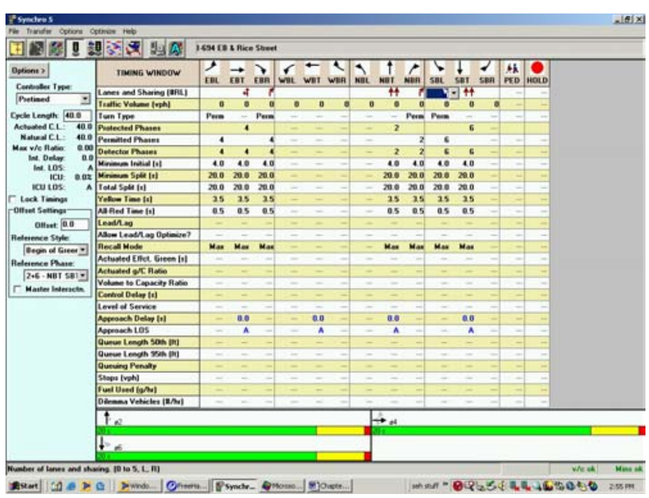
Figure 28 – Synchro Layout.DAT Sample File

- Open the LAYOUT.DAT file in Notepad. Notepad is a text editor program that comes standard with Microsoft installation. Wordpad is an alternative text editor program that can be used. Replace the X and Y coordinates in this file with the real world coordinates. Maintain the right column position in the text file. The column INTID summarizes the node number. After editing, save the file.

- Return to the Database Access menu and the LAYOUT tab. Select the LAYOUT.DAT file that you just edited. Select the READ button with the cursor and click the left button. The new coordinates will be read into the Synchro file. **DO NOT SELECT THE WRITE BUTTON, YOU WILL LOSE ALL OF YOUR WORK!** The Synchro file is now coordinate correct and ready for the next steps.

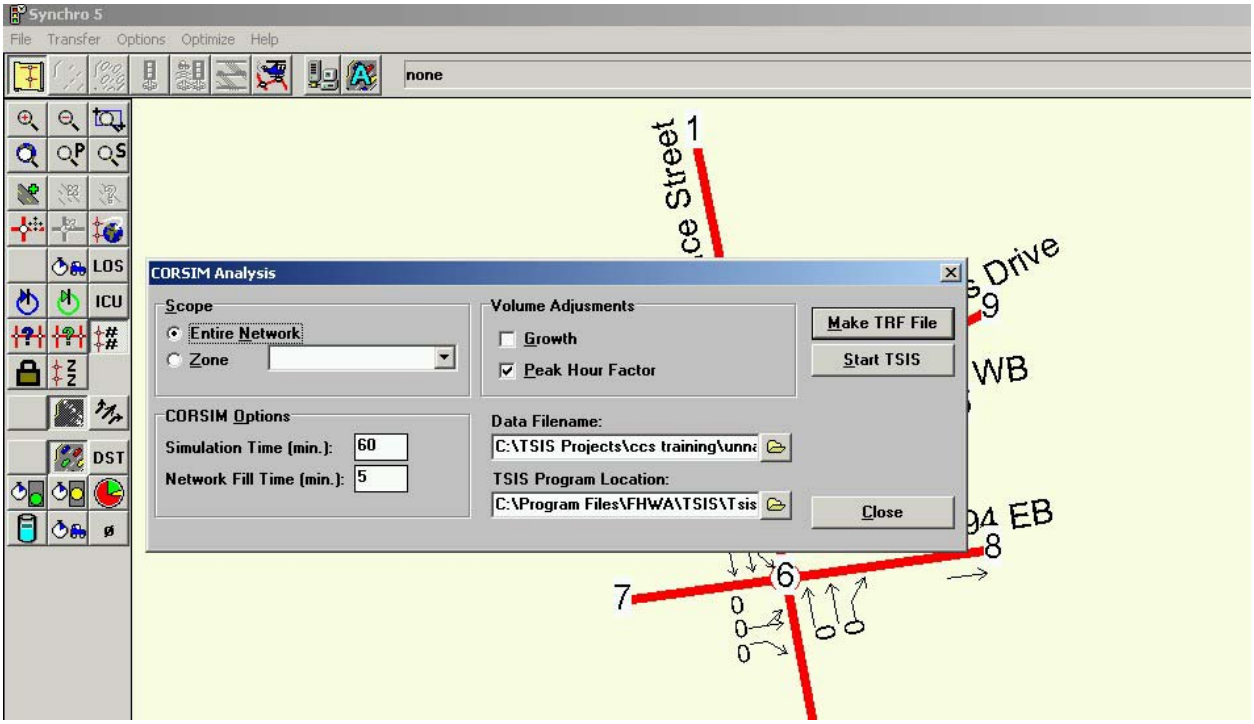
4.4.2 Step 3: Update Signal Timings

During the data gathering stage, signal timing sheets and signal design plans should have been gathered. At this point, the phasing, intervals, and minimum green times should be set based on field reports. Signal timings should be updated to reflect phasing, clearance intervals. Refer to Mn/DOT's Signal Timing and Optimization Manual for signal timing criteria.



4.4.3 Step 4: Transfer Synchro File to CORSIM

(CAUTION – DO NOT NAME THE SYNCHRO FILE THE SAME AS THE FREEWAY FILE!)



4.4.4 Step 5: Run Synchro Generated CORSIM File

Review and make changes to the Synchro file and retransfer to CORSIM as needed. At this point, you should have a NETSIM file that accurately represents the arterial system.

4.5 Part IV: Combining Freeway and Arterial Models

At this point, the modeler has two independent models, a freeway model and an arterial model, for one peak hour period. Part IV is the point in the process where the two different submodels are combined into one main model. After the combined model is working, data entry for the multiple time periods is created. The working model with multiple time periods is run, and an MOE report of the model run is created. With all of this information in hand, a final error check of the model can be conducted before proceeding to the calibration process. Chapter 5 outlines the structure of model materials and the review of the model inputs. The individual steps to combining models are discussed in the following sections.

4.5.1 Step 1: Combine Freeway and Arterial *.TRF Files

This step presumes that all the freeway models have been combined. If this has not happened, refer back to Section 4.3.10. This step also assumes that all intersections in the arterial model are in one *.trf file. If they are not, they must be combined in a similar fashion as combining the freeway models. Presumably, all the signalized intersections at multiple interchanges were developed in one Synchro model and transferred into one *.trf file. The CORSIM input file (*.trf) structure is based on RT numbers that must be in numerical order and grouped by submodel. The following graphic is a reminder of the model structure that must be considered when combining submodel files. A detailed description of the RTs can be found in the TSIS Users Manual, refer to Figure 24 on page 51.

The general process for combining FRESIM and NETSIM models from separate files is as follows:

- In text edit, open the freeway model file and save this file with a different name. Next in Text edit, open the *.trf file for the arterial model and select everything from RT 11 through RT 170. Copy and paste this information back into the renamed file right after RT 5.

- Return to the arterial *.trf file and copy the RT 195 and 196 information. Paste this information at the end of the RT 195 information. Save the combined file. Close the arterial file.

- In RT 2, change entry 14 from 8 to 3.

- In RT 170 at the end of the arterial network, change entry 1 from 0 to 8.

RT 170: Entry-Specific Data

ENTRY	STR COL	END COL	NAME	TYPE	RANGE	UNITS	DEFAULT
1	1	4	Code indicating the Next Section	Integer	0,3,8	Not Applicable	0
2	78	80	Record Type	Integer	170	Not Applicable	None

- Save file.
- To make sure that the models survived this process, go ahead and run the file and view the animation. You should have the interchanges in the proper locations, and traffic should be moving, but not between the freeways and arterials.

4.5.2 Step 2: Connect the Two Models in TRAFED

- Translate the *.trf file to a TRAFED file.
- Open the TRAFED file. Go to each ramp where the freeway and arterials network should be connected, and delete the entry and exit links. After these links are deleted, an interface link is created by selecting “create a one-way link” and selecting the “from” node and dragging and connecting to the “to” node. When one-way links are created between the two model types, an interface node is automatically created.
- Change the interface node to match the master link node diagram.
- Save the file after all interface connections have been created.

4.5.3 Step 3: Run Combined Model

Translate the *.tno file back to a *.trf file. Run the model and review the animation to make sure all connections have been properly made. If not, return to TRAFED and repeat Step 2.

At this point, celebrate; you have achieved a significant milestone in the process.

4.5.4 Step 4: Finalize QA/QC

Celebration is over; you have more work to do.

The *.trf file with the combined models needs to be organized to facilitate the QA/QC of the inputs, to develop an organized output structure, and to facilitate the development of volume inputs for multiple time periods.

<u>Freeway Submodel</u>

Based on the work done to organize the freeway model, this work will be minimal. RT 19 and RT 20 information should be sequenced in the same order with each freeway direction grouped together in order of consecutive mainline links followed by the ramp links.

TRAFED creates a RT 25 entry for every link in the freeway model. This input is only required at exit ramps, delete all RT 25s with 100 percent through traffic and 0 percent exit traffic.

<u>Arterial Submodel</u>

RT 11 and RT 21 information should be resorted in the same sequence. The important links are all links entering intersections. Each link entering an intersection should be grouped together; exit links and dummy links should be at the end.

The raw input from Synchro will not follow a logical sequence conducive for reviewing inputs and MOEs.

The input information should be incorporated into the QA/QC form.

4.5.5 Step 5: Develop Input for Multiple Time Periods

CORSIM allows for the model to be divided into different time periods and within the time periods certain inputs can be modified. The maximum number of intervals that can be modeled is 19, and the maximum time within each interval is 9,999 seconds. The primary information that can be altered from interval to interval is traffic volumes and signal timings.

The main reason for a freeway model to include multiple intervals is to change the volume inputs over the entire time period. Even though CORSIM is a stochastic model, traffic output will closely match the input volumes. So if the peak hour flow rates are coded in the model, the fluctuation within the peak period will not be realized. Mn/DOT requires that traffic conditions are modeled in CORSIM taking into account traffic fluctuations. The interval length that has been decided upon is 15-minute intervals over the course of the peak period. The peak period in the metro area is 3 hours; out-state areas may be less than this depending on prevailing traffic conditions.

Developing inputs for multiple time periods can be accomplished efficiently if the input file has been organized and the traffic volume data is in a database format that can be converted into model input.

The structure of the input file with multiple time periods is illustrated in Figure 29 below. The time period one input occurs in the main input portion of the model. Following the coordinate information are the additional time periods. The arterial model first followed by the freeway model information. A RT 170 and 210 separates each time period.

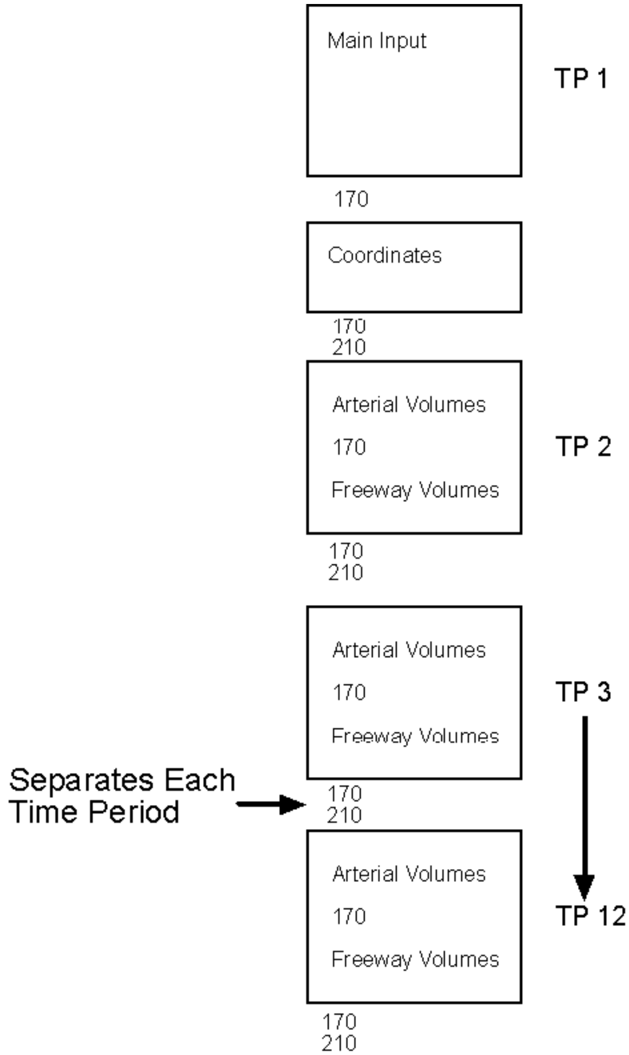


Figure 29 – Multiple Time Period Model Structure

The database for freeway volumes on the instrumented system shall be organized into rows for each station and ramp detector and the volume intervals will occur by columns. If the project is not on the instrumented system, the data should be arranged in a similar fashion and project stations should be created. Figure 30 below is a sample database format. Arranging the freeway data into this format will allow you to more easily cross correlate the volume data, which will be useful during the calibration process.

			Time Period											
	type		1	2	3	4	5	6	7	8	9	10	11	12
Description	**m, off, on**	**Station**	15:30:00	15:45:00	16:00:00	16:15:00	16:30:00		17:00:00	17:15:00	17:30:00	17:45:00	18:00:00	18:15:00
NB 35W/TH62 before Lyndale on R	m	50	1213	1278	1268	1293	1216	1268	1199	1189	1090	1161	1207	1378
NB - Lyndale on Ramp	on	125	136	112	128	137	147	149	172	173	166	151	142	110
NB 35W/TH62 before EB TH62 off	m	50a	1349	1390	1396	1430	1363	1417	1371	1362	1256	1312	1349	1488
NB - EB TH62 off Ramp	off	167	359	376	407	410	417	480	452	429	392	402	442	398
NB 35W - before WB TH62 on Ramp	m	51	990	1014	989	1020	946	937	919	933	864	910	907	1090
NB - WB TH62 on Ramp	on	126	454	425	450	443	466	458	459	482	446	417	435	417
NB 35W - before 60th St on Ramp	m	52	1444	1439	1439	1463	1412	1395	1378	1415	1310	1327	1342	1507
NB - 60th Street on Ramp	on	127	58	60	60	52	48	52	49	60	56	55	57	57
NB 35W - between 60th and DLR	m	52a	1502	1499	1499	1515	1460	1447	1427	1475	1366	1382	1399	1564
NB - Diamond Lake Rd off Ramp	off	168	42	39	45	46	49	49	54	64	67	70	74	77
NB 35W - at Diamond Lake Rd Bridge	m	53	1460	1460	1454	1469	1411	1398	1373	1411	1299	1312	1325	1487
NB - Diamond Lake Rd on Ramp	on	128	69	71	70	71	65	66	69	67	73	78	86	85
NB 35W - between DLR and 46th	m	54	1529	1531	1524	1540	1476	1464	1442	1478	1372	1390	1411	1572
NB 35W - between DLR and 46th	m	55	1529	1531	1524	1540	1476	1464	1442	1478	1372	1390	1411	1572
NB - 46th Street off Ramp	off	169	84	94	85	84	88	98	87	96	107	115	102	122
NB 35W - at 46th Street	m	56	1445	1437	1439	1456	1388	1366	1355	1382	1265	1275	1309	1450
NB - 46th Street on Ramp	on	129a	143	155	164	146	181	177	174	158	185	187	202	161
NB 35W - between 46th and 36th	m	57	1588	1592	1603	1602	1569	1543	1529	1540	1450	1462	1511	1611
NB 35W - between 46th and 36th	m	58	1588	1592	1603	1602	1569	1543	1529	1540	1450	1462	1511	1611
NB - 36th Street off Ramp	off	170	86	95	93	95	91	95	86	84	86	89	95	97
NB 35W - between 36th and 35th	m	59	1502	1497	1510	1507	1478	1448	1443	1456	1364	1373	1416	1514
NB - 35th Street on Ramp	on	130a	233	203	190	208	203	164	195	171	194	186	207	212
NB 35W - between 35th and 31st	m	59a	1735	1700	1700	1715	1681	1612	1638	1627	1558	1559	1623	1726
NB - 31st Street off Ramp	off	171	170	181	191	197	179	199	168	174	165	168	222	237
NB 35W - after 31st off Ramp	m	60	1565	1519	1509	1518	1502	1413	1470	1453	1393	1391	1401	1489
NB 35W - between 31st and Diverge	m	61	1565	1519	1509	1518	1502	1413	1470	1453	1393	1391	1401	1489
NB 35W - between 31st and Diverge	m	62	1565	1519	1509	1518	1502	1413	1470	1453	1393	1391	1401	1489
NB - TH65 Diverge	off	64	704	748	681	720	744	675	664	647	619	601	620	707
NB 35W - after TH 65 Diverge	m	63	861	771	828	798	758	738	806	806	774	790	781	782
NB - 5th Avenue on Ramp	on	2130	138	124	150	152	149	142	144	129	117	107	103	83
NB 35W - after 5th Ave on Ramp	m	565	999	895	978	950	907	880	950	935	891	897	884	865
NB - EB 94 on Ramp	on	2191	329	324	355	360	354	354	353	356	353	345	327	295

Figure 30 – Sample Freeway Volume Database Structure

Turning movement counts shall be assembled into a database structure to facilitate multiple time period inputs. A sample format for structuring turning movement counts is illustrated in Figure 31 below.

	Rice St.				694 WB Exit				Vadnais Blvd.				Rice St.			
Link	**905-901**				**906-901**				**908-901**				**900-901**			
	SBL	SBT	SBR	DIAG	WBL	WBT	WBR	DIAG	WBL	WBT	WBR	DIAG	NBL	NBT	NBR	DIAG
7:00	2	211	46		64	0	10	28		22	5	54	33	49		18
7:15	2	233	55		51	0	8	30		28	5	75	46	59		16
7:30	1	212	52		78	0	15	46		26	9	75	41	60		19
7:45	1	217	47		81	0	13	45		26	12	77	48	69		19
8:00	4	155	44		79	0	11	41		20	7	53	45	64		17
8:15	5	139	47		80	0	14	42		18	5	71	31	84		28
8:30	5	146	39		51	0	10	26		17	6	37	35	80		29
8:45	3	146	30		52	0	11	38		15	2	28	33	66		18
16:00	5	130	24		79	0	16	114		6	1	36	60	183		26
16:15	6	126	20		65	0	17	122		6	6	40	53	179		25
16:30	10	113	20		62	0	20	109		5	10	29	53	199		36
16:45	6	110	16		75	0	15	142		5	5	25	55	200		21
17:00	7	116	22		85	0	10	121		16	11	42	41	198		16
17:15	3	130	16		89	0	19	134		13	6	33	37	183		26
17:30	6	136	14		58	0	22	103		14	6	30	43	175		38
17:45	3	117	30		79	0	20	128		19	4	34	48	180		28

Figure 31 – Sample Intersection Volume Database Structure

Before using any of the information in the databases above, it is important to ensure that the traffic balances for **<u>all</u>** time periods. If the counts do not balance, the model results will never match the data as it was entered. This may lead you down the wrong path of changing calibration parameters and other settings to achieve the correct outcome.

The freeway inputs that need to be entered for each time interval are RT 25, 50, and 74. RT 25 is straightforward and can be taken directly from the table. RT 50 is the entering volume in vph; each 15-minute volume needs to be converted into hourly flow rates by multiplying the volume by four. RT 74 is the O-D information. The O-D percentages will change from time period to time period. Therefore, the O-D matrix that was developed earlier will need to be used again to calculate the O-D for each time interval.

The arterial inputs that need to be modified from interval to interval include RT 21, 50, and 22 if used. RT 21 is straightforward and is equal to the 15-minute volumes for each turning movement. RT 50s are the entering volumes; the 15-minute volumes must be converted into hourly flow rates by multiplying the 15-minute volumes by four. RT 22 defines discharge turn percentages based on entry movements and is used to correctly model conditions within interchanges. RT 22 is used at ramps to ensure that traffic does not reenter the freeway and that ramp demand volumes are satisfied.

4.5.6 Step 6: Run Model

After the volume data is entered into the model for the multiple time periods, run the model five times with different random number seeds.

4.5.7 Step 7: Summarize MOE Outputs

After the model has been run, the output is processed into tables that summarize output information. For freeway models, the key information is volume throughput, speed, density, and LOS information. Figure 32 below is a partial sample of MOEs from a freeway model. Notice that the node structure flows in sequence and the entire eastbound I-694 freeway segment can be analyzed at a glance. This table is the backbone information for the freeway model. It is from this table that report tables and graphics are prepared (see Chapter 7).

Location		Node		Length	Volumes			Link Statistics			Aggregate Statistics			Total Thruput		
From	To	From	To	(ft)	Actual	Simu-lated	Differ-ence	Speed (mph)	Density (vplpm)	LOS	Speed (mph)	Density (vplpm)	LOS	Actual	Simu-lated	Differ-ence
NB I-35W		300	301	1,012	3,300	3,319	19	49	22	C				10465	10,502	37
		301	304	1,973	3,300	3,322	22	49	22	C	49	22	C	10465	10,487	22
	EB TH 62 Entrance	304	305	1,068	3,300	3,328	28	48	23	C				10465	10,482	17
EB TH 62 Entrance	WB TH 62 Entrance	305	306	210	5,200	5,246	46	47	28	C				16047	16,069	22
WB TH 62 Entrance	60th Street Entrance	306	308	1,315	6,900	6,963	63	52	27	C				20999	21,049	50
60th Street Entrance	Diamond Lake Road Exit	308	310	863	7,260	7,326	66	56	22	C				21861	21,902	41
Diamond Lake Road Exit	Diamond Lake Road Entrance	310	315	2,341	7,190	7,271	81	61	24	C				21620	21,649	29
Diamond Lake Road Entrance		315	316	2,634	8,040	8,101	61	57	28	C				23616	23,618	2
	46th Street Exit	316	317	1,461	8,040	8,115	75	61	26	C	58	27	C	23616	23,607	-9
46th Street Exit	46th Street Entrance	317	319	2,426	7,919	7,986	67	56	28	D				23240	23,182	-58
46th Street Entrance		319	321	854	9,489	9,519	30	52	30	D				27058	26,935	-123
		321	323	1,755	9,489	9,521	32	54	29	D	55	28	D	27058	26,913	-145
	36th Street Exit	323	325	1,671	9,489	9,515	26	58	27	C				27058	26,905	-153
36th Street Exit		325	326	1,014	9,338	9,373	35	56	33	D				26594	26,441	-153
	35th Street Entrance	326	327	1,760	9,338	9,356	18	53	36	E	54	35	E	26594	26,416	-178
35th Street Entrance	31st Street Exit	327	328	715	10,759	10,756	-3	43	42	E				30301	30,218	-83
31st Street Exit	Lake Street Transit Exit	328	397	298	10,028	10,008	-20	43	39	E				27852	27,824	-28
Lake Street Transit Exit		397	329	1,242	10,028	9,983	-45	49	40	E				27852	27,777	-75
		329	330	346	10,028	9,977	-51	52	38	E				27852	27,771	-81
	Lake Street Transit Entrance	330	331	1,072	10,028	9,967	-61	52	37	E	51	38	E	27852	27,745	-107
Lake Street Transit Entrance		331	332	125	10,028	9,977	-51	53	32	D				27852	27,775	-77
		332	334	1,367	10,028	9,964	-64	54	36	E				27852	27,757	-95
	Downtown/WB I-94 Exit	334	336	1,875	10,028	9,961	-67	56	35	D				27852	27,718	-134
Downtown/WB I-94 Exit		336	695	228	4,078	4,109	31	60	23	C				11581	11,569	-12
		695	696	150	4,078	4,109	31	59	11	B				11581	11,568	-13
		696	697	153	4,078	4,109	31	57	12	B	54	21	C	11581	11,568	-13
		697	337	299	4,078	4,107	29	52	26	C				11581	11,567	-14
	EB I-94 Exit	337	338	411	4,078	4,106	28	50	22	C				11581	11,564	-17
EB I-94 Exit	5th Avenue Entrance	338	340	740	2,768	2,787	19	45	21	C				8079	8,078	-1
5th Avenue Entrance	EB I-94 Entrance	340	342	1,081	3,438	3,459	21	51	19	B				9760	9,758	-2
EB I-94 Entrance	EB I-94 Exit	342	344	1,394	5,048	4,770	-278	50	24	C				14304	13,616	-688
EB I-94 Exit		344	370	350	4,659	4,386	-273	47	31	D				13374	12,667	-707
	Washington Ave. U of M Exit	370	345	800	4,659	4,384	-275	51	24	C	49	26	C	13374	12,662	-712
Washington Ave. U of M Exit		345	346	336	3,419	3,228	-191	56	19	B				10022	9,522	-500
	NB TH 55 Entrance	346	348	521	3,419	3,226	-193	58	19	B	57	19	B	10022	9,520	-502
NB TH 55 Entrance		348	349	2,490	4,330	4,123	-207	58	18	B				12312	11,799	-513
	NB I-35W	349	350	677	4,330	4,121	-209	58	18	B	58	18	B	12312	11,797	-515
TH 62 EB		400	401	909	1,900	1,907	7	49	20	B				5582	5,598	16
		401	402	1,664	1,900	1,909	9	49	20	B				5582	5,597	15
		402	403	2,052	1,900	1,912	12	46	21	C	47	23	C	5582	5,593	11
		403	404	845	1,900	1,914	14	44	25	C				5582	5,592	10
		404	406	605	1,900	1,914	14	46	42	E				5582	5,589	7
TH 62 EB Entrance	NB I-35W	406	305	125	1,900	1,915	15	46	42					5582	5,588	6
TH 62 WB Entrance	NB I-35W	405	306	1,040	1,700	1,711	11	48	36					4952	4,987	35
60th Street Entrance		407	408	330	360	359	-1	22	8					862	861	-1
	NB I-35W	408	308	682	360	359	-1	37	7					862	861	-1
	Diamond Lake Road Exit	310	410	401	70	67	-3	55	1					241	248	7
Diamond Lake Road Entrance		414	415	68	850	826	-24	8	43					1996	1,988	-8
	NB I-35W	415	315	356	850	825	-25	31	16					1996	1,985	-11
	46th Street Exit	317	417	445	121	139	18	54	2					376	406	30
46th Street Entrance		418	419	84	1,570	1,534	-36	7	89					3818	3,765	-53
	NB I-35W	419	319	559	1,570	1,531	-39	34	30					3818	3,763	-55
	36th Street Exit	325	425	116	151	141	-10	61	2					464	444	-20
35th Street Entrance		426	427	143	1,421	1,414	-7	9	73					3707	3,816	109
	NB I-35W	427	327	426	1,421	1,413	-8	32	31					3707	3,815	108
	31st Street Exit	328	428	134	731	745	14	51	14					2449	2,388	-61
	Lake Street Transit Exit	397	498	332	0	9	9	29	0					0	32	32
Lake Street Transit Entrance	NB I-35W	430	331	746	0	9	9	29	0					0	32	32
	Downtown/WB I-94 Exit*	336	600	339	5,950	5,844	-106	53	35					16271	16,147	-124
	EB I-94 Exit	338	719	540	1,310	1,322	12	50	25					3502	3,480	-22
5th Avenue Entrance	NB I-35W	440	340	375	670	669	-1	54	11					1681	1,681	0
EB I-94 Entrance	NB I-35W	818	342	344	1,610	1,315	-295	50	26					4544	3,867	-677
	EB I-94 Exit	344	825	560	389	382	-7	52	6					930	944	14
	Washington Ave. U of M	345	445	543	1,240	1,156	-84	53	10					3352	3,136	-216
NB TH 55 Entrance	NB I-35W	448	348	360	911	910	-1	54	16					2290	2,290	0

Figure 32 – Sample MOE Report Freeways

Similar to the freeway information, arterial data is processed and summarized into tables. Figure 33 below is a sample table of arterial output. The information includes volume throughput, control delay, and maximum queues. The table should also highlight problem areas that affect arterial and freeway performance, such as ramp intersections operating at LOS E or F and links where queues exceed storage length.

Key arterial MOE include approach and intersection control delay and LOS, throughput, and storage and queue information.

TABLE G-2
riod
Arterial Measures of Effectivness

Select Time Period:
7:00 AM-8:00 AM

Location	Aprch	Link	Demand volumes				Model - Demand		LOS by Approach		LOS by Intersection		Modeled Storage & Maximum Traffic Queueing (feet)					
													Through		Left Turn		Right Turn	
			Lt	Th	Rt	total	Total	%	Delay	LOS	Delay	LOS	Link Length	Queue	Storage	Queue	Storage	Queue
Lake Street at Stevens	SB	545-513	14	169	11	194	0.6	0%	21	C	16	B	586	72				
	WB	514-513	157	548	0	705	159.6	23%	11	B			326	160	80	80		
	EB	512-513	0	619	149	768	-5.6	-1%	21	C			328	156			80	40
Lake Street at 2nd	WB	515-514	0	699	15	714	-3.6	-1%	23	C	13	B	334	176			80	28
	NB	510-514	166	402	133	701	2.8	0%	5	A			618	60				
	EB	513-514	78	699	0	777	-156.4	-20%	12	B			326	168				
31st at Stevens	SB	513-509	15	424	40	479	34	7%	13	B	16	B	618	144			80	20
	WB	510-509	146	189	0	335	75.4	23%	17	B			328	148				
	EB	508-509	0	145	167	312	0.2	0%	20	B			330	120			80	80
31st at 2nd	WB	511-510	0	298	10	308	-1	0%	16	B	13	B	332	80				
	NB	539-510	112	666	152	930	20	2%	14	B			282	288				
	EB	509-510	24	172	0	196	-31.6	-16%	7	A			328	52				
35th at Stevens	SB	522-505	0	469	308	777	44.4	6%	16	B	15	B	292	184			150	76
	WB	506-505	159	235	0	394	-0.6	0%	14	B			332	96	150	128		
35th at 2nd	WB	507-506	0	322	211	533	2	0%	23	C	22	C	351	172				
	NB	502-506	72	1373	0	1445	17.4	1%	21	C			659	356	150	84		
36th at 2nd	NB	525-502	0	409	86	495	-2.4	0%	28	C	29	C	252	236			150	48
	EB	501-502	1290	487	0	1777	-319.2	-18%	29	C			333	312	150	160		

Figure 33 – Sample MOE Report Arterials

It is easier to review model inputs and check for errors when a model that has been run for the full duration of the modeling period has been completed and MOE summaries have been prepared. Large discrepancies in volume outputs can be an indicator of an error in volume inputs. Large discrepancies in volume output and extremely poor operations that are unexpected may indicate incorrect lane geometry or signal timings.

5.0 Chapter 5 – Model Organization & Review of Inputs

QA/QC of a CORSIM model is important due to the simple fact that on a typical project, there is large amount of information that has been developed, synthesized, and entered into the model. A typical model could have as much as 3,000 lines of input; finding mistakes in a file of this size could be like finding a needle in the haystack.

The reality of any simulation modeling is that it is a human process, and we, as humans, will make mistakes. In order to ensure we have a quality process, systems need to be developed that allow the user to organize and automate input in order to reduce mistakes, and with that organization, allow someone else to review the inputs. This manual and the methods have been developed to organize every aspect of preparing a CORSIM model so that creating a quality model is easier to do and will allow a manager or peer to review the work in a timely fashion.

There are an infinite number of ways of using the input programs, text files, spreadsheets, and programs to prepare a CORSIM model. These methods and organizational techniques have been developed for Mn/DOT staff and consultants to follow so that the modeling requirements can be implemented more efficiently.

The rest of this chapter defines the organizational structure for electronic files and provides checklists for reviewing various aspects of the model. Implicit in the discussion is that the procedures for creating the model as described in Chapter 4 were followed. If the model was created without the systems in Chapter 4, the time it will take to perform the QA/QC checks will increase substantially. Based on recent experiences, it has been easier to completely redo a model that was not developed using Chapter 4 techniques than to try and review a model that is disorganized.

5.1 Organization of Model Data

There are a number of setup files and background pieces of information that go into preparing a simulation model. A very effective way to organize all of the information that went into a model is to prepare a model manual. The model manual is both a hard copy document and electronic file system. The file structure is a consistent system that, if uniformly used, ensures efficient review of the model inputs.

The model manual includes all the information that went into the model and includes the calibration and MOEs summary. Figure 34 is a screen capture of the model manual structure. During the model process and especially if there are multiple people working on the same model, files may reside temporarily on individual hard drives. This is acceptable while work is in progress, however, at the end of the day, the final products need to be collected into the uniform manual structure.

There should be a model manual prepared for existing conditions (calibration) and for each primary alternative considered. Subalternatives (modified primary alternatives) can be collected into the same manual by using subheadings under the main categories using the alternative description as a folder name. This will be explained further as each folder is described in detail.

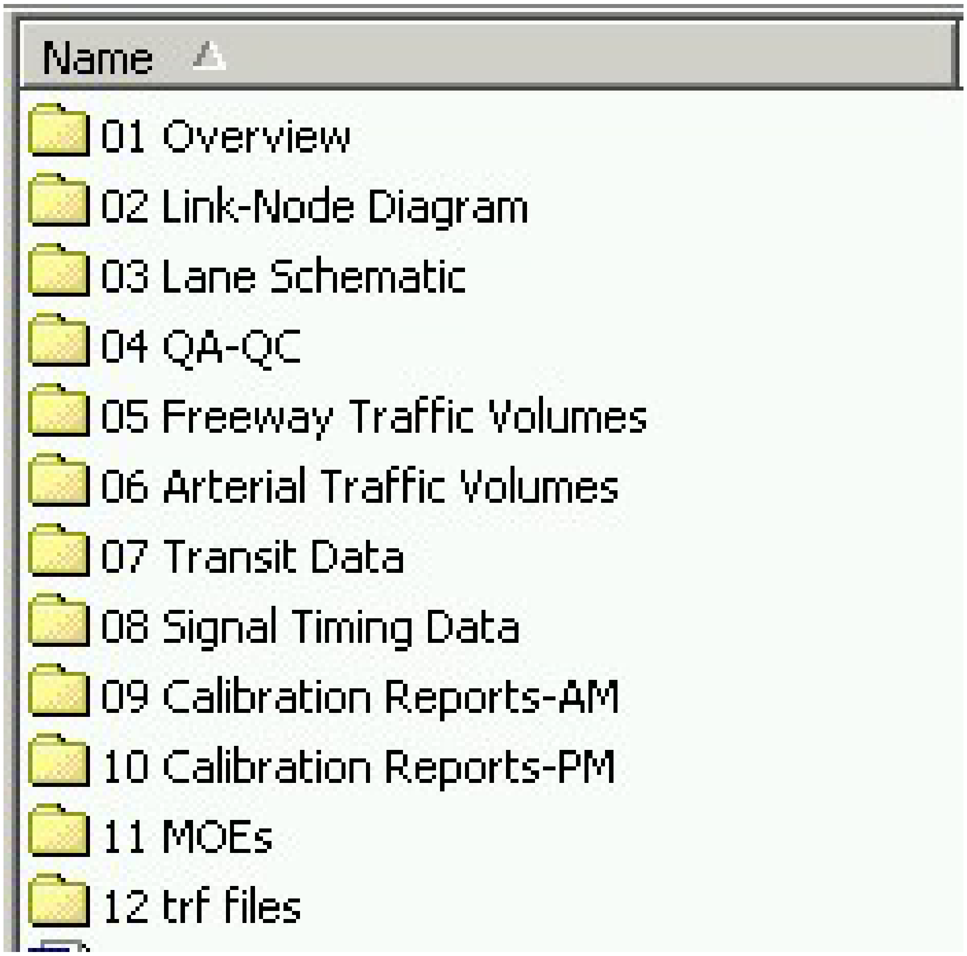


Figure 34 – Model Manual File Structure

What should go into the individual folders? The following descriptions will provide guidance as to what should go into each of the folders illustrated in Figure 34. The suggested file structure may be modified according to the needs of the project. The manual is not a report; it is a technical appendix with the explicit purpose of providing documentation of the CORSIM model to the reviewer. Given the type of information and format of the forms, preparing the manual in an 11x17 format is suggested.

01 Overview Within this folder, any text files or charts/tables that describe the project and/or the alternatives contained within the manual should be provided.

02 Link Node Diagram This folder should include both a paper and electronic copy of the link node diagram. The link node diagram should conform to the format as described in Chapter 4, which is a diagram on base mapping in real coordinates. For practical reasons, it is useful to prepare the link node diagram into 11x17 "plan sheets" at 300 scale.

	The link node diagram, depending on the project, may also be needed in one continuous roll plan as well.
03 Lane Schematic	The lane schematic folder includes the coding diagrams that are defined in Chapter 4.
04 QA/QC	In Chapter 4, the QA/QC tables were identified. All files pertaining to review of the physical inputs of the model belong here.
05 Freeway Volumes	This folder includes all raw count data and input volumes for the CORSIM model including O-D matrices and RT 25 and RT 50 inputs. Subfolders should be used to separate raw data from CORSIM inputs.
06 Arterial Volumes	This folder includes all turning movement count data and input volumes for the CORSIM model including RT 21, RT 22, and RT 50 inputs. Subfolders should be used to separate raw data from CORSIM inputs.
07 Transit Data	This folder is used only if buses are included in the model. Transit data would include route and stop information, Metro Transit ridership, and dwell time information. The source transit data needs to be converted into CORSIM inputs; these conversion tables should be saved in this folder.
08 Signal Timings	This folder includes signal design plans, timing sheets, field observation notes, and Synchro files.
09 Calibration Reports AM	This folder includes documentation of modifications made to the model to calibrate the AM peak conditions. The folder includes the calibration statistics and graphs that compare modeled volumes and speeds against observed speeds and volumes. This process is discussed in detail in Chapter 6. The calibration folders need not be used in the manuals for future alternatives, calibration only occurs for existing conditions.
10 Calibration Reports PM	This folder includes documentation of modifications made to the model to calibrate the PM peak conditions. The folder includes the calibration statistics and graphs that compare modeled volumes and speeds against observed speeds and volumes. This process is discussed in detail in Chapter 6. The calibration folders need not be used in the manuals for future alternatives; calibration only occurs for existing conditions.

11 MOEs	This folder includes all tables and figures that summarize the MOEs from every model set of runs.
12 TRFs	This folder includes all CORSIM input files *.trfs, *.tno, and *.out files. Documentation of random number seeds used should be included. *.tsd files should not be collected into the final model manual folder. These files can be over 1 gigabyte in size and will exceed the capacity of a data CD. By including the *.trf files, the reviewer will be able to copy the desired *.trf file to run on a hard drive and review the animation.

Other folders can be created as needed. The first 12 folders represent the essential information for CORSIM modeling that is needed for the review process.

5.2 Review of Physical Inputs

The process for reviewing the physical inputs of the model is to compare the information on the link node diagram and lane schematic against the input file. For freeway models, the QA/QC summary sheet combines the physical input information on a link-by-link basis that correlates to the diagrams. Again, if the model was prepared without using these techniques, the reviewer essentially has to recreate the model to ensure that the physical inputs have been coded properly.

The following sections provide lists and discussion of what is looked for in the review and what should be included. The methods for preparing the diagrams and summaries have been described in Chapter 4.

The review process should happen in stages. Before the calibration process can begin, a thorough review of the physical inputs and traffic volumes should be conducted. When mistakes are identified early, the calibration process is not as difficult.

5.2.1 Physical Input Review – Freeways

Review of the physical inputs of the freeway model includes the following items:

- <u>Node Locations and Link Lengths.</u> Nodes should be located according to the criteria in Chapter 4, lengths of links, especially around curves needs to be verified. The lengths will be verified by scaling distances from the link node diagram and comparing the value to the input file. Node locations should have been reviewed and agreed upon at an earlier stage; however, the independent reviewer will inspect the node locations and verify that the node criteria have been satisfied.
- Accel/Decell Lane Lengths
- Number of Lanes and Lane Alignment
- Lane Drops/Lane Adds
- Ramp Meter Locations

- Ramp Meter Timings
- Free Flow Speeds
- Curvature
- Grades

5.2.2 Physical Input Review – Arterials

Physical arterial reviews occur in the NETSIM submodel the items include.

- Link Distances, Stop Bar to Stop Bar
- Lane Utilization
- Storage Lane Lengths
- Free Flow Speeds
- Signal Timings

5.3 Review of Traffic Volume Inputs

Traffic volume inputs, especially for multiple time periods, are a challenge to review. In an input file with 3,000 lines of code, over 2,000 lines could be devoted specifically to traffic volume data. If the volume data was manually entered in the file (i.e., each value was manually entered in TRAFED or TextEdit), it is almost impossible to check. If spreadsheet tools were used to enter the input information, the review is possible and can be done efficiently. The following questions will be considered by the reviewer.

5.3.1 Traffic Volume Inputs Freeway

Does the O-D matrix for each time period balance?

Do the overall freeway volumes balance?

How was the input information created? Is the input linked to a balanced database or was it manually entered?

5.3.2 Traffic Volume Inputs Arterials

Does the turning movement data balance for each time period?

Does the conditional turn movement coding balance?

6.0 Chapter 6 – Calibration Process

Calibration of a CORSIM model occurs only for the existing models. The model is calibrated when the volume, speed, and other operational observations are satisfactorily replicated. Calibration information from the existing model is carried forward to the alternatives analysis. If traffic does not get through an alternative model or if there is congestion in an alternative, then the alternative does not work, and either the geometry or signal timings should change, not the driver behavior or the calibration parameters.

The importance of calibration extends beyond the statistical tests. The changes made to achieve a valid statistical model need to reflect reality. Were car following parameters changed to unrealistic parameters to achieve calibration? Were artificial constraints put in the model to make congestion occur? It is very critical that an organized process be followed to achieve calibration. In example, changing multiple variables at one time can make it difficult to determine what caused the correct response. However, calibration cannot go on forever, and testing the effects of single changes in large models could take too long.

The approach and information provided in this chapter are a guide to calibration. Being successful and proficient at calibrating a model is based on experience. **Experience has proven that the number one step in calibrating a model is to have the base model set up properly and to have a good handle on conditions in the field. This means watching and understanding how the system really operates – knowing where the congestion occurs and why the congestion occurs along the system. Without a "good" model and a thorough understanding of the field conditions, calibration is a meaningless exercise with no end.**

6.1 Causes of Congestion

Congestion on roadways is caused by a number of different factors. Too much traffic, bottlenecks caused by changes in geometry, and incidents are some of the causes. Micro-simulation models including CORSIM require extensive inputs to reflect the real world. The first step is to get the basic information entered correctly: the number of lanes, storage lanes, balanced traffic volumes, and signal timings. Having this information entered correctly may not replicate the congestion that is observed. It may be necessary to adjust the operating characteristics of a link, such as the modeled desired speed, may need to be lowered or the headway spacing increased to reflect the localized congestion. The process to identify causes of congestion and adjusting the model to reflect these causes is iterative between field observations and running the model. The table below provides some insights into causes of congestion and potential model treatments. This list cannot cover every situation, and some the suggested model modifications may not be the complete answer (i.e., there may be other causes of congestion or other changes need to be made than what is suggested). Each model will be unique; however, the current project efforts on major portions of the metro freeway system have provided more refined insights into calibration. Please contact Mn/DOT to discuss calibration issues.

Table 4
Causes of Congestion

Observed Congestion Cause	Potential Model Modifications
Inadequate sight distance caused by: - Tight horizontal curvature - Lateral obstructions or lack of clear zone space - Short vertical curve	Curves and grades should already be reflected in the base model. However, it is possible for the desired modeled speed that is adjusted internally by the radius of curve and/or grade, to not go low enough to replicate the congestion. Drivers in the field may be responding differently, **Adjust the desired free flow speed or headway spacing.** Lateral obstructions may cause drivers to hesitate through that segment of freeway. **Adjust the desired free flow speed or headway spacing.**
Poor or Inadequate Signing	Drivers in the model using exit ramps begin to change lanes to position themselves for the exit at the warning sign location entered in RT 20. The default warning sign location is 2,500 feet. **Adjust the warning sign location in RT 20 to reflect the observed condition.**
Poor Interchange Spacing	Poor interchange spacing is reflected in the way the base model is constructed, (i.e., entrance and exit ramps are close together creating short weave sections). Usually when interchanges are spaced close together, there is very little ramp-to-ramp traffic creating more of a weave. To replicate congestion, **make sure to incorporate an O-D matrix.**
Lane Continuity	Lane continuity on a mainline freeway allows through vehicles to stay in the left hand lanes without any lane changing. Loss of lane continuity usually occurs through a systems interchange. The lane changing or shifts in these cases are caused by drivers given a choice of a destination. If the freeway splits at the systems interchange are not included in the model, traffic will operate in a free state not creating congestion. **Expand the model to include a portion of the systems interchange and incorporate into the O-D matrix.**
Lane Drops	Lane drops are coded directly in the CORSIM model. The important attributes to be observed and adjusted in the model are the warning sign location.
Bad Weather	Typically, design alternatives are not modeled for bad weather. FHWA is currently researching how to use CORSIM to test the effects of bad weather.
Poor Signal Timings	Identify the timings in the field and modify the timings in the model to reflect the field. When using Synchro to set up CORSIM, it is easy to incorrectly export optimal timings.
Construction	Testing the effects of construction can be done a number of different ways in CORSIM. The base model can be changed to reduce the number of lanes or long-term incidents can be used.
Incidents or Crashes	Modeling incidents or crashes is typically not part of the design process. However, if it is desired to examine this condition, CORSIM allows for modeling short and long-term incidents. Short-term incidents are randomly placed throughout the modeling period for the specified links. Long-term incidents are coded with a specified start and end time and for a specific location.
Events	Modeling events requires changing the volume inputs and signal timings to reflect the event condition.

6.2 Calibration Approach

The approach to calibrating a model is to run the model and conduct statistical checks. If the statistics are acceptable, then the model is calibrated. If they are not, then modify the model until the statistics are acceptable. The approach to modifying the model for the purpose of calibration should be to change known global parameters and link level parameters first, and as a last resort, change unknown global parameters. Recent modeling experiences in the metro area have shown that it is possible to have different driver responses to the same circumstances depending on the location within the same model area. **Changing the car following sensitivity parameters without working through the link level conditions first will result in an unrealistic model.** If the modeler is trying to achieve a local change by using global parameters, then the results may never be achieved for the right reasons.

The following steps are given in an order and are intended only to provide a start point. At times, they may need to be done in conjunction or in a different sequence to determine the appropriate coding. In addition to these parameters, it may be necessary to change the physical geometry of the model to achieve results. For instance, if there is a downstream exit ramp that was not included in the model in the beginning, and yet it was determined in later review after the model was prepared that in order to get the vehicles to line up in the proper lanes that it should be added, then this is also part of calibration. **During the course of calibrating a model, the modeling limits may have to be adjusted to replicate existing conditions.**

6.2.1 Step 1: Modification of Known Global Parameters

Mn/DOT has identified two global parameters that must be incorporated into every mode. These two parameters are detailed below. At the start of the calibration process, this information should be coded directly into the input file.

6.2.1.1 <u>Headway Distributions</u>

There are three (3) stochastic *vehicle entry headway* choices: uniform distribution, normal distribution, and Erlang distribution. This is the method the program will use to generate vehicles at entry nodes. The default setting is a uniform distribution, but the preferred choice is a normal distribution for arterials and Erlang for freeways. For the Erlang distribution, the parameter “a” is set to 1.

6.2.1.2 <u>Fleet Information</u>

The main calibration parameters for the CORSIM model are the vehicle type characteristics found under the Network Properties menu. Up to nine (9) different types of vehicles can be simulated by the model. Four (4) different classes of vehicles can be modeled: auto, truck, transit, and carpool. For Mn/DOT modeling purposes, the following vehicles have been adopted:

1. 15-foot long auto
2. 30-foot long single unit truck (SUT)
3. 62-foot long semi-trailer
4. 40-foot long transit bus

The main variables for the vehicle types include:

1. Maximum non-emergency deceleration
2. Maximum emergency deceleration

To determine the headway between vehicles, the model uses the maximum deceleration rates. Altering these rates gives the user some control over the density of the system. The maximum deceleration rate of the program has been capped at 15 ft/s^2. For the vehicles listed above, the following deceleration rates have been selected as beginning points for calibration:

Vehicle Type	Max. Non-Emergency Deceleration ft/sec^2	Max. Emergency Deceleration ft/sec^2
15-foot auto	13.1	15.0 (actual = 23.0)
30-foot SUT	9.8	15.0 (actual = 16.4)
62-foot semi	7.9	12.5
40-foot bus	9.8	15.0 (actual = 16.4)

The physical makeup of the traffic can also be entered. At entry links, the truck percentages can be entered. Within the vehicle type characteristics, the user can define the makeup of each vehicle class for either arterial or freeway systems. This is entered as a percentage, and the sum of the percentages must equal 100 for each vehicle class. For example, the truck class could be entered as 65 percent SUT and 35 percent semi-trailers. **Current fleet percentages shall be used in the model. This information is available by contacting the Mn/DOT Planning section.**

It is important that the fleet information vehicle be coded for both the freeway and arterial models. There are some inconsistencies between the two submodels, so this vehicle information needs to be coded twice in a slightly different manner. This information is subject to change; the latest fleet information should be requested from Mn/DOT at the start of the modeling process.

```
NETSIM global vehicle parameters

    5  15         100                         25   0   0   0                 130  58
    1  15         100                         75   0   0   0                 130  58
    2  30         120                          0  60   0   0                 120  58
    6  62         120                          0  40   0   0                 120  58
    3  19         100                          0   0   0 100                 250  58

 FRESIM global vehicle parameters
   20  15   1  30   5   4 130 130 100  80  35  80 100  80  70 100  15          70
    1  15  70 150  50   0   0   0   2 130                                      71
    2  15  70 150  50   0   0   0   2 130                                      71
    3  30  70 150   0  60   0   0   3 120                                      71
    4  62  70 150   0  40   0   0   5 120                                      71
    5  53  70 150   0   0   0   0   5 120                                      71
    6  64  70 150   0   0   0   0   6 120                                      71
    8  14  70 150   0   0   0  50   1 250                                      71
    9  19  70 150   0   0   0  50   2 250                                      71
```

Figure 35 – CORSIM Model Fleet Information Codes

6.2.2 Step 2: Modification of Local or Link Length Parameters

Local conditions (link level) within the model are the anticipatory speed and warning sign location. These parameters apply to all on ramp locations and provide information to vehicles on the mainline upstream of the merge. The message is that if the entering vehicle speed drops below the specified value, the vehicles within the warning sign location on the mainline will change lanes to avoid the merging vehicle. Figure 36 illustrates this condition.

The default conditions in the model are 43 mph anticipating speed and the warning sign located 1,500 feet upstream of the merge. A recent crash statistic for the state of Minnesota indicated that Minnesota is twice the national average in accidents caused by failing to yield. Generally, during the peak conditions, very little cooperation is given at entrance ramps. However, some locations are better than others. Much of this has to do with the other ramp destinations and prevailing conditions so it needs to be addressed on a case-by-case basis. **If the failure to yield at an entrance ramp is very high, then the anticipatory speed should be very low, and the warning sign should be placed very close to the ramp.** If the yield conditions are very generous, which usually occurs in out-state areas under lower traffic flows, the default parameters are probably acceptable.

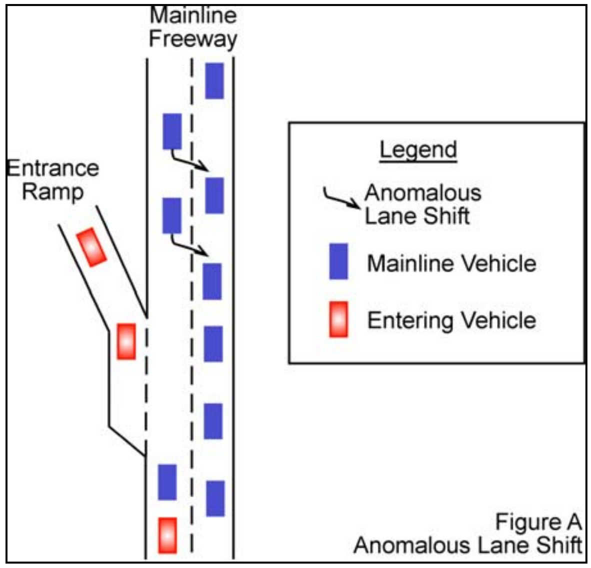


Figure 36 – Anticipatory Lane Change Parameter Illustration

6.2.2.1 Adjust Warning Sign Locations for Exit Ramps and Lane Drops

The default setting for where vehicles begin to change lanes to get to an exit ramp is 2,500 feet. In Minnesota, drivers tend to line up for exits beyond this limit. Field observations are important to make an estimate of when vehicles begin to line up for an exit. This occurs on westbound I-94 in Rogers at the TH 101 exit. At this location, the right lane of eastbound I-94 has a moving queue that is 5 miles long.

6.2.2.2 Adjust Free Flow Speeds/Headway Factors

Under certain circumstances, it may be necessary to lower the free flow speed and/or the headway factor on a link or a series of links. The modeler should correlate this change in the model to a geometric issue that may cause drivers to behave differently. In example, these parameters may require adjustment due to a sight distance constraint caused by a barrier or a bridge abutment. It is important to observe congestion in the field and try to identify the cause. If the congestion does not have something to do with warning signs or a ramp and only occurs at one location in the model, then adjusting the free flow speed or increasing the headway factor should be considered.

6.3 Model Run Parameters

The run parameters for the model include the minimum number of runs with different random number seeds required. There is a statistical test that should be applied to determine the sample size (number of runs). This involves picking a confidence level and percent error. For instance, 95th percentile confidence with a 5 percent error. When applying this test to a data set the number of runs required could be few or as many as 30. At this time, the required minimum number of runs with different random number seeds is 5.

6.4 Statistical Evaluation Process

6.4.1 Calibration Testing Process

1. Calculate the average volumes for ramp entry and exit points and mainline sections representing detector stations. This is done for each time interval.
2. For each detector location, graph the simulated volume and detector volumes against time. Visually inspect graphs for large differences in volumes and for simulation delays.
3. Calculate residual errors for each time interval at each ramp and detector station. Check for large residual errors occurring at entry ramps and exit ramps. These are indications of volume coding errors, particularly at entry links. When the residual errors are within 10 percent of the detector data, the simulated volumes are considered acceptable.
4. Review volume data in simulation files after the first run to check for possible coding errors suggested by the graphs and/or residuals.
5. Calculate the average speed for mainline sections representing detector stations. This is done for each time interval.
6. Compare mainline speeds at the detector stations to verify that the model is simulating the same congestion levels as the mainline detectors. When the simulated speeds are within 20 percent of the estimated detector station speeds, the speeds are considered acceptable.
7. Compare the actual ramp queue lengths with the simulated values to verify that ramps are servicing the same number of vehicles. When the residual errors are within 10 percent of the detector data, the simulated volumes are considered acceptable. Differences could be due to a coding error on ramp speed or value.

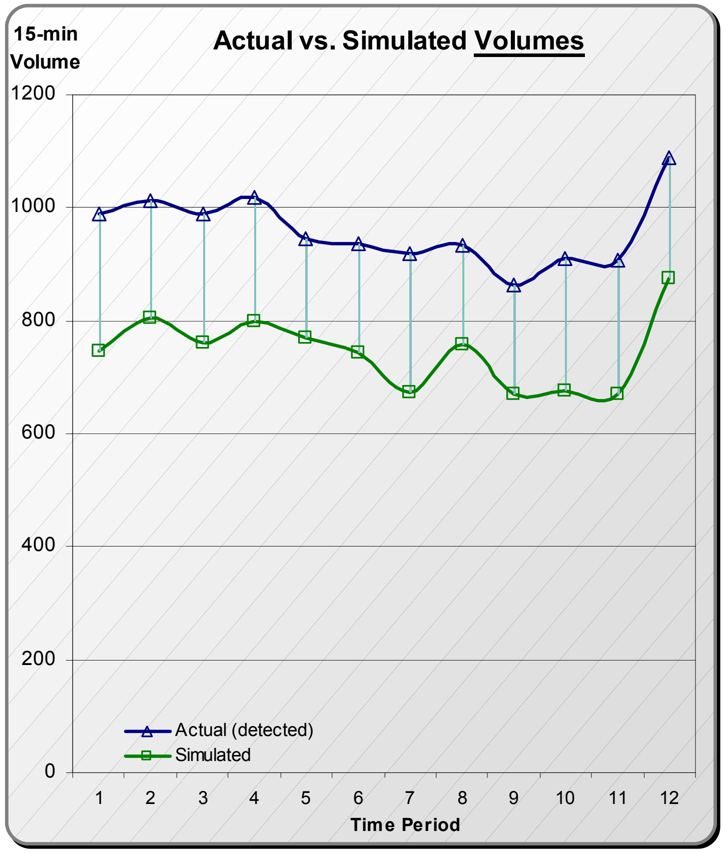


Figure 37 – Sample Statistical Calculations and Graph

6.5 Global Changes – Unknowns

As a last resort, global car following and basic vehicle response parameters should be modified and tested. Changing these parameters requires a more rigorous set of model runs to validate that the car following model should be modified.

<u>Car Following Model</u>

FRESIM parameters include driver behaviors, lane change parameters, and model parameters. These are best left in their default settings. The one model parameter that can be modified is the *minimum separation for generation of vehicles* parameter. This is the minimum time the model uses to produce vehicles at entry links and is the only parameter that controls freeway capacity. But, this is only true at the entry links and does not affect the other links in the modeled system. Entered in seconds, this parameter has a default value of 1.6 seconds that equals a capacity value of 2250 vplph.

To determine this parameter, the mainline entry point detector volumes, in vph, are plotted against their occupancy rates. From this graph, the maximum volume is determined and is divided into 3,600. Auxiliary lane detectors should not be included in this calculation.

There are a large number of parameters for NETSIM including several parameters for driver behaviors. All of these should be left in their default settings.

7.0 Chapter 7 MOEs and Reports

CORSIM models produce a lot of information. Depending on the size of the network, the amount of information can be overwhelming. Organizing the MOEs output from the different model scenarios in a project requires thoughtful consideration. The modeler must be able to convey the results from the entire model, as well as be able to highlight problem areas that require extra attention.

Developing both tabular and graphical displays of the model results should be done. More information can be contained in a table than on a graphic, but the graphic is necessary to understand what was modeled. Using both of these methods of conveying information creates a better understanding of the modeling work.

7.1 Tabular Summaries

In Chapter 4, a MOE model report was developed to summarize detailed information from the model. This report is useful for the modeling process, but is cumbersome when conveying results from multiple alternatives and scenarios. This information should be extracted into easier to understand tables. Areas where multiple links were used between ramps can be consolidated into an aggregate segment statistic; this can be calculated by a weighted average based on the length of the link.

The key MOEs required for freeway analysis summaries include volume, speed, density, and LOS. When performing alternatives, analysis throughput should also be compared. The key MOEs required for arterial analysis summaries include intersection and approach delay and LOS, queue length, and storage length.

7.1.1 Tables Summarizing Model Results

There are a number of table formats that can be assembled for a project. The first sets of tables are MOEs of the entire model run. These types of reports are necessary to review volume differences and the performance of the model. These tables are necessary to review the model. These tables provide the information used to create graphical summaries and comparative tables.

TABLE AM-1
2002 AM Peak Period
Freeway Measures of Effectivness
I-494 from TH 5 to TH 55, Minnetonka MN

Select Hour Interval: 7:00 AM-8:00 AM

	Location		Node		Length (ft)	Volumes			Link Statistics			Aggregate Statistics			Total Thruput		
	From	To	From	To		Actual	Simu-lated	Differ-ence	Speed (mph)	Density (vplpm)	LOS	Speed (mph)	Densit y	LOS	Actual	Simu-lated	Differ-ence
NB 494 Mainline	NB	Begin 494 NB	110	111	1,490	1,941	1,942	1	68	14	B				5,349	5,347	-2
	NB		111	112	398	1,941	1,941	0	68	14	B	68	14	B	5,349	5,347	-2
	NB	Valley View Entrance Ramp	112	113	1,493	2,509	2,493	-16	63	15	B				6,554	6,536	-18
	NB		113	114	798	2,509	2,491	-18	67	18	B				6,554	6,535	-19
	NB		114	115	1,101	2,509	2,489	-20	67	18	B	65	17	B	6,554	6,533	-21
	NB		115	116	1,000	2,509	2,486	-23	66	18	B				6,554	6,534	-20
	NB	TH 62 Exit Ramp	116	117	1,560	2,509	2,486	-23	66	16	B				6,554	6,529	-25
	NB	TH 62 Bridge	117	118	1,147	2,151	2,125	-26	67	15	B				5,696	5,662	-34
	NB		118	119	985	2,151	2,123	-28	66	16	B	67	15	B	5,696	5,659	-37
	NB	TH 62 Entrance Ramp	119	120	1,505	2,960	2,889	-71	57	22	C				7,683	7,585	-98
	NB		120	121	2,142	2,960	2,883	-77	66	21	C				7,683	7,580	-103
	NB		121	122	1,066	2,960	2,881	-79	66	21	C				7,683	7,575	-108
	NB		122	123	926	2,960	2,880	-80	66	21	C	64	21	C	7,683	7,571	-112
	NB		123	124	1,077	2,960	2,880	-80	65	21	C				7,683	7,569	-114
	NB		124	125	1,213	2,960	2,880	-80	65	21	C				7,683	7,569	-114
	NB		125	126	685	2,960	2,878	-82	65	21	C				7,683	7,565	-118
	NB	TH 7 Exit Ramp	126	127	1,529	2,960	2,882	-78	65	19	B				7,683	7,560	-123
	NB	Before TH 7 Weave	127	128	1,093	2,892	2,816	-76	62	21	C	62	21	C	7,519	7,397	-122
	NB	TH 7 Weave	128	129	374	3,826	3,748	-78	34	36	E	34	36	E	10,060	9,956	-104
	NB	After TH 7 Weave	129	130	1,276	3,571	3,488	-83	51	33	D	51	33	D	9,329	9,233	-96
	NB	TH 7 Entrance Ramp	130	131	1,517	3,753	3,673	-80	58	29	D				9,776	9,677	-99
	NB		131	132	1,733	3,753	3,670	-83	64	28	C	62	26	C	9,776	9,670	-106
	NB	Minnetonka Exit Loop	132	133	1,476	3,753	3,667	-86	64	22	C				9,776	9,662	-114
	NB	Minnetonka Bridge	133	134	500	3,487	3,408	-79	62	27	C				9,177	9,071	-106
	NB		134	135	461	3,487	3,407	-80	58	28	D	60	27	C	9,177	9,069	-108
	NB	Minnetonka Entrance Ramp	135	136	1,538	3,914	3,816	-98	55	30	D				10,242	10,091	-151
	NB		136	137	950	3,914	3,815	-99	63	29	D				10,242	10,088	-154
	NB		137	138	1,639	3,914	3,808	-106	63	29	D	61	29	D	10,242	10,086	-156
	NB		138	139	1,550	3,914	3,802	-112	64	28	D				10,242	10,081	-161
	NB		139	140	1,400	3,914	3,800	-114	62	30	D				10,242	10,077	-165
	NB	394 Exit Ramp	140	141	1,530	3,914	3,801	-113	61	27	C				10,242	10,072	-170
	NB	Before 394 Weave	141	142	1,104	3,173	3,068	-105	65	21	C	65	21	C	7,926	7,813	-113
	NB	394 Weave	142	143	468	3,485	3,383	-102	60	13	B	60	13	B	8,710	8,587	-123
	NB	After 394 Weave	143	144	1,105	3,044	2,941	-103	64	18	B	64	18	B	7,505	7,406	-99
	NB	394 Entrance Ramp	144	145	973	4,106	3,973	-133	60	20	C				10,232	10,117	-115
	NB	Carlson Exit Ramp	145	146	943	4,106	3,970	-136	63	20	B	62	20	B	10,232	10,114	-118
	NB	Carlson Bridge	146	147	1,158	3,466	3,351	-115	65	24	C				8,758	8,667	-91
	NB		147	148	1,377	3,466	3,345	-121	65	24	C	65	24	C	8,758	8,662	-96
	NB	Carlson Entrance Ramp	148	149	1,536	3,668	3,549	-119	65	17	B				9,290	9,189	-101
NB 494 Ramps	NB	Valley View Entrance Ramp	213	212	747	568	555	-13	43	5					1,205	1,195	-10
	NB	Valley View Entrance Ramp	212	112	242	568	555	-13	24	10					1,205	1,195	-10
	NB	TH 62 Exit Ramp	117	217	176	358	362	4	44	7					858	867	9
	NB	TH 62 Entrance Ramp	220	219	379	809	775	-34	7	55					1,987	1,932	-55
	NB	TH 62 Entrance Ramp	219	119	453	809	773	-36	33	12					1,987	1,931	-56
	NB	TH 7 Exit Ramp	127	227	455	68	63	-5	44	1					164	161	-3
	NB	TH 7 Entrance Loop	252	251	99	934	936	2	24	19					2,541	2,562	21
	NB	TH 7 Entrance Loop	251	250	140	934	936	2	10	45					2,541	2,560	19
	NB	TH 7 Entrance Loop	250	228	111	934	935	1	23	20					2,541	2,560	19
	NB	TH 7 Entrance Loop	228	128	226	934	935	1	27	21					2,541	2,561	20
	NB	TH 7 Exit Loop	129	229	238	255	255	0	30	8					731	722	-9
	NB	TH 7 Entrance Ramp	231	232	750	182	191	9	42	2					447	453	6
	NB	TH 7 Entrance Ramp	232	230	283	182	187	5	5	20					447	451	4
	NB	TH 7 Entrance Ramp	230	130	415	182	187	5	30	3					447	451	4
	NB	Minnetonka Exit Loop	133	233	172	266	256	-10	34	6					599	588	-11
	NB	Minnetonka Entrance Ramp	236	235	590	427	416	-11	42	4					1,065	1,026	-39
	NB	Minnetonka Entrance Ramp	235	135	313	427	414	-13	38	6					1,065	1,026	-39
	NB	394 Exit Ramp	141	241	672	741	731	-10	53	14					2,316	2,256	-60
	NB	394 Entrance Loop	1617	242	175	312	317	5	29	5					784	775	-9
	NB	394 Entrance Loop	242	142	173	312	317	5	29	9					784	775	-9
	NB	394 Exit Loop	143	243	250	441	439	-2	31	12					1,205	1,176	-29
	NB	394 Entrance Ramp	244	144	423	1,062	1,034	-28	48	12					2,727	2,714	-13
	NB	Carlson Exit Ramp	146	246	282	640	618	-22	44	12					1,474	1,445	-29
	NB	Carlson Entrance Ramp	249	248	100	202	208	6	41	2					532	534	2
	NB	Carlson Entrance Ramp	248	148	506	202	210	8	40	3					532	534	2

Figure 38 – Sample FRESIM Moe Summary Report

TABLE ART-1a
2002 AM Peak Period
Arterial Measures of Effectivness
I-494 from TH 5 to TH 55, Minnetonka MN

Select Time Period: 7:00 AM-8:00 AM

Location	Aprch	Link	Demand volumes				Modeled Volumes				Demand Volumes			Model - Demand		Total Delay by Movement			Total Delay by Movement			Level of Service by			LOS by Approach		LOS by Intersection		Modeled Storage & Maximum Traffic Queueing (feet): Through		Left Turn		Right Turn	
			Lt	Th	Rt	total	L	T	R	total	L	T	R	Total	%	L	T	R	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Link Length	Queue	Storage	Queue	Storage	Queue
Valley View East Ramp	WB	902-901	240	908	0	1148	232	898	0	1130	-8.4	-9.8	0	-18.2	-2%	62	58	0	16	4	-	B	A	-	6	A	8	A	596	108				
	EB	910-901	0	192	328	520	0	193	327	520	0	1.4	-1.2	0.2	0%	0	27	29	-	8	5	-	A	A	6	A			349	56				
Valley View West Ramp	WB	901-902	0	192	0	192	0	191	0	191	0	-1	0	-1	-1%	0	70	0	-	22	-	-	C	-	22	C			596	64				
	SB	912-902	424	0	165	589	413	0	164	577	-11	0	-0.8	-11.8	-2%	116	0	19	17	-	7	B	-	A	14	B	17	B	714	192				
	EB	913-902	0	724	0	724	0	720	0	720	0	-4	0	-4	-1%	0	131	0	-	11	-	-	B	-	11	B			739	108				
TH 62 East Ramp	WB	904-903	335	2490	0	2825	330	2436	0	2766	-5.4	-53.8	0	-59.2	-2%	351	510	0	64	13	-	E	B	-	19	B			455	420	350	336		
	SB	921-903	0	510	474	984	0	531	457	988	0	21	-17.4	3.6	0%	0	46	95	-	5	13	-	A	B	9	A	16	B	763	120				
	EB	923-903	179	0	179	358	179	0	174	353	-0.2	0	-4.8	-5	-1%	138	0	117	46	-	40	D	-	D	43	D			675	100	400	108	400	220
TH 62 West Ramp	WB	903-904	87	602	0	689	85.4	623	0	709	-1.6	21.2	0	19.6	3%	40	98	0	28	9	-	C	A	-	12	B			455	116	350	128		
	SB	922-904	0	1845	211	2056	0	1847	217	2064	0	1.8	6.4	8.2	0%	0	424	30	-	14	8	-	B	A	13	B	25	C	702	324				
	EB	924-904	980	0	161	1141	921	0	147	1068	-59	0	-13.8	-72.8	-6%	1111	0	25	72	-	10	E	-	B	64	E			442	464			400	72
Mtka East Ramp	WB	906-905	0	1050	0	1050	0	1046	0	1046	0	-4.4	0	-4.4	0%	0	157	0	-	9	-	-	A	-	9	A			857	128				
	SB	925-905	0	405	98	503	0	403	94.6	498	0	-2	-3.4	-5.4	-1%	0	125	9	-	19	6	-	B	A	16	B			514	228				
	EB	931-905	0	26	240	266	0	30.4	224	255	0	4.4	-15.8	-11.4	-4%	0	12	21	-	24	6	-	C	A	8	A			500	64				
Mtka West Ramp	WB	905-906	0	282	363	645	0	270	356	627	0	-11.8	-6.6	-18.4	-3%	0	61	63	-	13	11	-	B	B	12	B			857	136				
	SB	907-906	341	0	341	682	335	0	346	681	-5.6	0	4.6	-1	0%	161	0	60	29	-	10	C	-	B	19	B			738	212				
	EB	928-906	472	709	0	1181	468	714	0	1181	-4.4	4.8	0	0.4	0%	103	101	0	13	8	-	B	A	-	10	B			551	164				
Mtka at McGinty West Ramp	WB	906-907	0	638	197	835	0	631	182	813	0	-7.4	-14.6	-22	-3%	0	210	25	-	20	8	-	B	A	17	B			738	360				
	SB	932-907	0	238	25	263	0	241	23	264	0	3.2	-2	1.2	0%	0	55	3	-	14	7	-	B	A	13	B			331	148				
	EB	953-907	0	593	0	593	0	590	0	590	0	-3.2	0	-3.2	-1%	0	65	0	-	7	-	-	A	-	7	A			913	76				
Carlson Pkwy East Ramp	WB	909-908	123	649	0	772	127	632	0	759	4	-17.2	0	-13.2	-2%	61	94	0	29	9	-	C	A	-	12	B			814	104	300	68		
	SB	951-908	170	0	470	640	163	0	452	615	-7.4	0	-17.6	-25	-4%	45	0	91	17	-	12	B	-	B	13	B			779	52	400	56	400	224
	EB	961-908	0	421	79	500	0	418	80.8	499	0	-2.8	1.8	-1	0%	0	126	9	-	18	7	-	B	A	16	B			468	108				
Carlson Pkwy West Ramp	WB	908-909	89	502	0	591	85.2	490	0	576	-3.8	-11.6	0	-15.4	-3%	39	56	0	28	7	-	C	A	-	10	A			814	52	300	48		
	SB	950-909	395	0	503	898	383	0	496	878	-12	0	-7.4	-19.8	-2%	112	0	124	18	-	15	B	-	B	16	B			1063	164	400	128	400	248
	EB	960-909	0	377	174	551	0	377	170	548	0	0.4	-3.8	-3.4	-1%	0	113	18	-	18	6	-	B	A	14	B			469	88			300	40
TH 62 at Beach/ Clearwater	WB	903-921	376	2266	27	2669	376	2184	24.4	2585	-0.2	-81.6	-2.6	-84.4	-3%	265	1270	8	42	35	19	D	C	B	36	D			763	676			400	28
	SB	957-921	12	0	9	21	12.4	0	8.6	21	0.4	0	-0.4	0	0%	11	0	2	51	-	17	D	-	B	38	D			202	20	145	20	90	20
	EB	958-921	23	3	42	68	22.2	1.8	43	67	-0.8	-1.2	1	-1	-1%	16	1	9	43	37	13	D	D	B	23	C			414	24	300	44	250	44
	NB	959-921	20	930	320	1270	23.8	938	312	1274	3.8	7.6	-7.6	3.8	0%	21	421	40	52	27	8	D	C	A	23	C			499	268				
TH 62 at Baker	WB	904-922	139	416	208	763	141	411	212	764	1.6	-4.6	3.6	0.6	0%	109	83	29	47	12	8	D	B	A	17	B			702	0	300			
	SB	967-922	42	163	490	695	44	158	488	690	2	-5	-2	-5	-1%	33	118	203	45	45	25	D	D	C	31	C			898	0			250	
	EB	968-922	70	1449	77	1596	70	1459	76.6	1606	0	10.2	-0.4	9.8	1%	75	755	33	64	31	26	E	C	C	32	C			1335	0	250		65	
	NB	969-922	117	107	52	276	113	102	54	269	-4	-4.6	2	-6.6	-2%	88	70	6	47	41	7	D	D	A	36	D			1200	0			250	

Figure 39 – Sample NETSIM MOE Report Table

7.1.2 Comparative Summary Tables

Comparative summary tables are necessary to filter the information from the model run reports to the essential information necessary for making a decision. Below are sample tables comparing the results for existing (2005) conditions and two alternatives each for opening year (2015) and future year (2025).

STH 35 Southbound Freeway Operations Summary

	Design Year									
	2005		2015 (a)		2015 (b)		2025 (a)		2025 (b)	
Analysis Segment	**Speed**	**Density/ LOS**	**Speed**	**Density/ LOS**	**Speed**	**Density/ LOS**	**Speed**	**Density/ LOS**	**Speed**	**Density/ LOS**
I-94 Eastbound Ramp	64(63)	N/A[1]	64(62)*	N/A[1]	64(63)	8/A (23/C)	64(63)	9/A (27/D)	(63)	(27 /D)
From I-94 merge to High Ridge Exit	64 (62)	5/A (13/B)	63 (61)*	7/A (15 /B)	64 (62)	6/A (16 /B)	64 (59)	7/A (20 /C)	(61)	(19 /B)
From High Ridge Exit to High Ridge Entrance	64 (64)	4/A (10 /B)	64 (64)*	5/A (9 /A)	65 (64)	5/A (11 /B)	65 (63)	6/A (13 /B)	(64)	(13 /B)
High Ridge Entrance	64 (63)	7/A (11 /B)	63 (63)*	8/A (11 /A)	63 (63)	9/A (13 /B)	62 (62)	11/B (15 /B)	(62)	(15 /B)

*600 vehicle per hour shortfall, results under-estimated

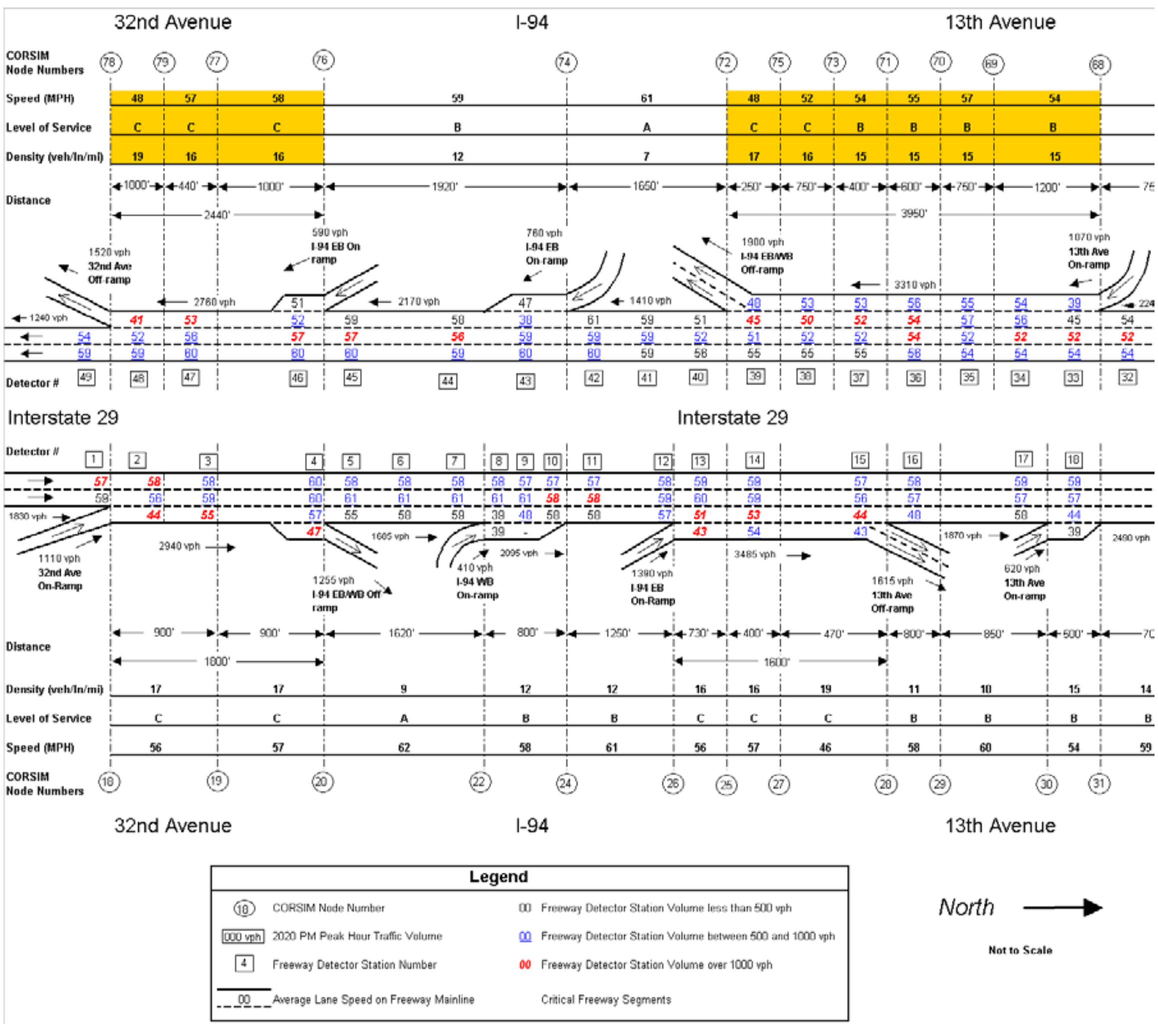
Northbound I-35W PM Peak Period Operational Comparisons
Interim Condition

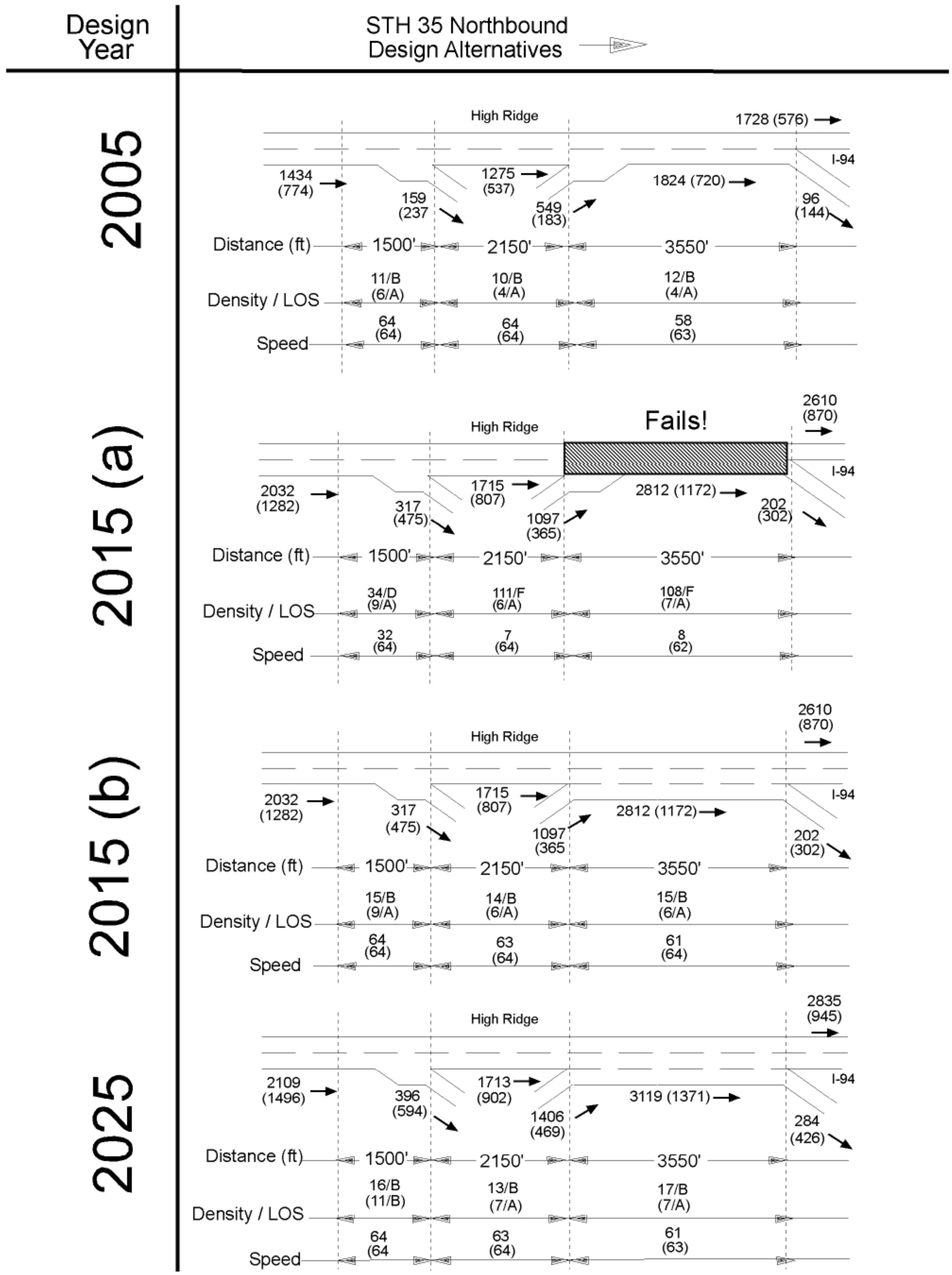
Segment Description		3 Hour Volume Served				3 Hour Volume Served				Peak Hour Density		
From	To	3d v2a	3d v2b	3d v2e	3d v2f	3d v2a	3d v2b	3d v2e	3d v2f	3d v2a	3d v2b	3d v2e
NB I-35W	EB TH 62 Entrance	8,955	8,951	8,951	8,953	3	0	0	2	21	21	21
EB TH 62 Entrance	WB TH 62 Entrance	13,192	11,881	13,193	13,194	1311	0	1313	1313	24	57	24
WB TH 62 Entrance	60th St Entrance	18,091	14,365	16,131	18,089	3726	0	1766	3724	24	84	36
60th St Entrance	Diamond Lake Rd Exit	18,820	14,636	16,418	18,815	4184	0	1782	4179	19	86	42
Diamond Lake Rd Exit	Diamond Lake Rd Entrance	18,096	13,874	15,900	18,101	4222	0	2026	4227	21	112	78
Diamond Lake Rd Entrance	46th St Exit	19,031	13,781	15,679	19,037	5250	0	1897	5255	21	123	115
46th St Exit	46th St Entrance	17,755	12,822	14,892	17,774	4933	0	2071	4952	31	135	92
46th St Exit	36th St Exit											
46th St Entrance	38th St Exit	19,885	14,569	16,452	19,903	5316	0	1883	5334	32	114	70
36th Street Exit	35th Street Entrance											
38th St Exit	38th St Entrance	18,716	13,883	15,266	18,716	4833	0	1382	4833	26	88	44
35th Street Entrance	31st St Exit											
38th St Entrance	31st St Exit	20,815	15,623	17,263	20,835	5191	0	1640	5211	24	62	35
31st St Exit	Lake St Transit Exit	19,439	14,409	16,048	19,405	5030	0	1639	4996	26	52	27
Lake St Transit Exit	28th St Exit	19,432	14,363	16,040	19,404	5069	0	1677	5042	25	51	24
28th St Exit	Lake St Transit Entrance	18,137	13,399	14,950	18,084	4738	0	1551	4685	35	51	22
Lake St Transit Exit	Lake St Transit Entrance											
Lake St Transit Entrance	Lake St Entrance	18,140	13,398	14,953	18,087	4742	0	1555	4690	44	46	20
Lake St Entrance	Downtown/WB I-94 Exit	20,901	16,067	17,613	20,829	4834	0	1546	4762	36	41	21
Lake St Transit Entrance	Downtown/WB I-94 Exit											
Downtown/WB I-94 Exit	5th Ave Entrance	9,779	7,331	8,095	9,692	2448	0	765	2361	50	23	27
Downtown/WB I-94 Exit	EB I-94 Exit (new)											
EB I-94 Exit	5th Ave Entrance											
5th Ave Entrance	EB I-94 Entrance	11452	9005	9766	11367	2448	0	762	2362	49	28	32
EB I-94 Entrance	EB I-94 Exit	15,752	13,362	13,854	15,662	2390	0	492	2300	46	28	31
EB I-94 Exit	Washington Ave U of M Exit	13,173	11,384	11,695	13,036	1789	0	311	1651	39	27	29
Washington Ave U of M Exit	NB TH 55 Entrance	10,912	9,576	9,809	10,819	1336	0	233	1243	37	30	32
NB TH 55 Entrance	NB I-35W	14,241	12,906	13,136	14,148	1335	0	230	1242	23	20	21
Downtown Spur												
35W Diverge		11,125	8,738	9,517	11,135	2388	0	780	2397	24	19	21
	WB I-94 Exit	11,123	8,739	9,518	11,134	2383	0	779	2395	26	21	23
WB I-94 Exit	Downtown	5,597	4,338	4,712	5,559	1258	0	374	1220	18	15	16

	Density Range from
LOS D	26
LOS E	35
LOS F	45

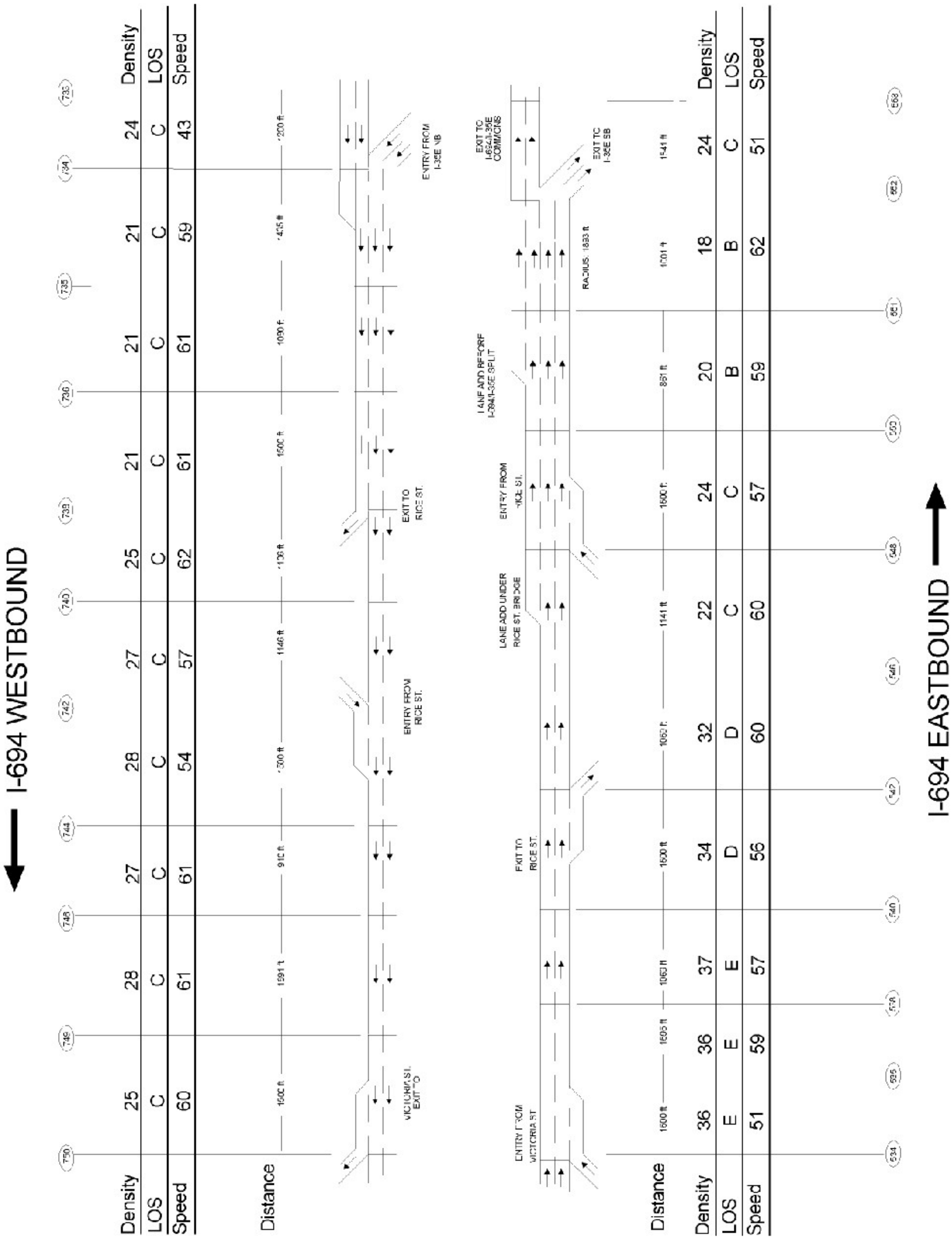
7.2 Graphical Summaries

Graphical summaries are prepared using lane schematic diagrams developed during the modeling process. The information can be displayed by a single alternative or with multiple alternatives on one page for a side-by-side comparison. Below are sample graphics of both types.





Design Year
STH 35 Northbound
Design Alternatives
2005
High Ridge
1728 (576)
I-94
1434 (774)
159 (237
1275 (537)
549 (183)
1824 (720)
96 (144)
Distance (ft)
1500'
2150'
3550'
Density / LOS
11/B (6/A)
10/B (4/A)
12/B (4/A)
Speed
64 (64)
64 (64)
58 (63)
2015 (a)
High Ridge
Fails!
2610 (870)
I-94
2032 (1282)
317 (475)
1715 (807)
1097 (365)
2812 (1172)
202 (302)
Distance (ft)
1500'
2150'
3550'
Density / LOS
34/D (9/A)
111/F (6/A)
108/F (7/A)
Speed
32 (64)
7 (64)
8 (62)
2015 (b)
High Ridge
2610 (870)
I-94
2032 (1282)
317 (475)
1715 (807)
1097 (365
2812 (1172)
202 (302)
Distance (ft)
1500'
2150'
3550'
Density / LOS
15/B (9/A)
14/B (6/A)
15/B (6/A)
Speed
64 (64)
63 (64)
61 (64)
2025
High Ridge
2835 (945)
I-94
2109 (1496)
396 (594)
1713 (902)
1406 (469)
3119 (1371)
284 (426)
Distance (ft)
1500'
2150'
3550'
Density / LOS
16/B (11/B)
13/B (7/A)
17/B (7/A)
Speed
64 (64
63 (64)
61 (63)


I-694 WESTBOUND
Density
LOS
Speed
Distance
25 28 27 28 27 25 21 21 21 24
C C C C C C C C C C
60 61 61 54 57 62 61 61 59 43
VICTORIA ST. EXIT TO
ENTRY FROM RICE ST.
EXIT TO RICE ST.
ENTRY FROM I-35E NB
I-694 EASTBOUND
36 36 37 34 32 22 24 20 18 24
E E E D D C C B B C
51 59 57 56 60 60 57 59 62 51
ENTRY FROM VICTORIA ST
EXIT TO RICE ST.
LANE ADD UNDER RICE ST. BRIDGE
ENTRY FROM RICE ST.
EXIT TO I-35E SB

7.3 Final Documentation

Documentation relating to CORSIM modeling is ongoing throughout a project. Intermediate technical memorandums, documentation of the model calibration, study reports, and interstate access requests are the types of documents that may need to be prepared. The number of deliverables should be scoped out at the beginning of the project. The number of documents necessary is proportionate to the size of the model and project. A larger project may require more intermediate documents to facilitate the decision-making process, whereas a smaller project may require one report. The following sections provide guidance to different types of documentation.

The graphics and reports discussed in Section 7.2 are to be used for documentation. The graphics and tables may be tailored to meet the needs of the project. The types of analyses and reports include the following:

- Alternative analysis
- Sensitivity analysis
- Calibration report/tech memo
- MOE report/tech memo

7.3.1 Model Manual

The model manual was discussed in Chapter 5. This is the documentation of the model inputs, field observations, calibration adjustments, and model results. The model manual is important in that all interstate access requests must have information sufficient for Mn/DOT and/or FHWA to conduct an independent analysis. Due to the stochastic nature of traffic models and the high probability of errors in model coding and incorrect judgment, these models must "hold" up to scrutiny. The model manual is an electronic submittal with hard copy printouts of project drawings and narrative descriptions of the material provided. The submittal shall include, but not be limited to, the following items:

- Link Node Diagrams for all alternatives in micro-station
  - Plan sheets of the link node diagrams should also be provided
- Lane Schematics
- QA/QC Tables
- Traffic Demand Data
  - Arterial turning movement counts raw and balanced summarized in the arterial database format illustrated in Chapter 4.
  - Freeway mainline and ramp traffic volumes (summarized in the format illustrated in Chapter 4
  - Balance traffic dataset
  - O-D matrix calculations summarized in the format illustrated in Chapter 4
- Traffic Control Data
  - Ramp metering rates
  - Signal timing data from signal controller printouts and field observations
- Transit Data
- Electronic Files
  - CORSIM *.trf files
  - Synchro files *.sy6 files

- CADD files
- Graphics and tables

7.3.2 Technical Memorandums

Technical memorandums are intermediate reports of technical issues pertaining to the model during the course of the project. These memos are usually defined at the beginning of the project; however, during the project, the need to elaborate on a particular issue may be necessary. Below are some of the intermediate tech memos that may need to be prepared.

- **Calibration Memorandum.** Summarizes the changes made related to calibration and provides justification for the changes and supportive statistics. MOEs including volume throughput and speed comparisons between observed and modeled must be included.

- **Traffic Forecasts and Forecasting Methodology.** Traffic forecasts need to be approved by Mn/DOT. Since forecasts need to be part of the alternatives analysis, they need to be finalized early in the process. This memorandum can be incorporated into the final documentation.

- **Intermediate Modeling Issues.** During the modeling process, unusual model problems may arise where an unconventional approach may be required. This may require documentation in support of a meeting to discuss the problem and potential solutions.

- **MOE Summary Report.** The results of an analysis may be summarized in a summary report that contains the MOEs for the alternatives tested.

7.3.3 Freeway Study Report

The Freeway Study Report is an intermediate document that is used to discuss in detail design, traffic forecasts, and operational issues for all alternatives considered for either an interchange modification or new interchange access request. The Freeway Study Report should be written to contain the information necessary to prepare the interstate access request document. This document may contain more information and provide documentation of alternatives considered. A sample outline is as follows:

I. Project Overview
II. Existing Conditions
    A. Traffic Operations
    B. Geometry
    C. Crashes
III. Traffic Forecast Methodology
IV. Interchange Design Selection
V. Year Opening Analysis
    A. Build
    B. No-Build

VI. Future Year Analysis
   A. Build
   B. No-build
VII. Sensitivity Analysis
VIII. Safety Analysis
VIII. Conclusion

If the findings and recommendations are agreed to in the Freeway Study Report, then the Freeway Study Report can be appended to include a discussion of the eight policy items that need to be satisfied for interstate access approval.

7.3.4 Interstate Access Request

Final documentation includes technical memorandums, a Freeway Study Report, and an Interstate Access Report (IAR). Each study could have a slightly different focus, but the information requirements from the model and the method by which the model is prepared will be the same. IAR requirements are based on "Federal Highway Administration Docket No. 98-3460, Additional Interchanges to the Interstate System," Federal Register 63, February 11, 1998.

An IAR is required for all new or modified interchanges. Summarized below are the deliverables required to fulfill operational analysis requirements that feed into the IAR:

<u>Background</u>

The FHWA has retained all approval rights to the control of access to the interstate system. This is necessary to protect the integrity of interstate system and the extensive investment associated with it. To obtain approval from FHWA to access the interstate, a request for access, in conformance with this guidance, must be submitted to FHWA through the Mn/DOT.

FHWA access approval is required when access on the interstate system is added or modified. This applies to all access changes on the interstate system regardless of funding and oversight. Each entrance or exit point, including "locked gate" and temporary construction access, to the mainline interstate is considered to be an access point. This guidance is limited to:

- New Interchanges
- Modifications to existing interchanges involving access control revisions for new ramps or relocation or elimination of existing ramps
- Modification of the access control on arterial roadways at interchanges

Interchange reconfiguration is considered to be a change in access even though the number of actual points of access may not change. For example, replacing one of the direct ramps of a diamond interchange with a loop or changing a cloverleaf interchange into a fully directional interchange is considered as revised access.

Access approval is a two step process that was developed to help the state manage risk and provide flexibility. It is intended to identify fatal flaws and to help ensure the investment in the environmental document is not wasted. The first step is a finding of operational and engineering "acceptability". The second step is the final "approval". Often these are done at the same time; however, it is not necessary. The finding of operational and engineering acceptability is the more lengthy and time consuming of the two steps; it requires consideration of the eight policy points addressed hereinafter.

All new partial interchanges, new interchanges in the Metro Division, and new or major modifications to freeway to freeway interchanges go to FHWA headquarters in Washington, D.C. for this determination of "acceptability". Because both the Division Office and headquarter review the document, this could be a lengthy process. Final approval is relatively quick once the operational and engineering acceptability has been determined.

The FHWA approval constitutes a federal action and, as such, requires that National Environmental Policy Act (NEPA) procedures are followed. Compliance with the NEPA procedures need not precede the determination of engineering and operations "acceptability". However, final "approval" of access cannot precede the completion of NEPA. Once NEPA has been completed, "approval" of access is granted as long as no changes resulted to the "accepted" concept.

Access Request

The access request with a recommendation must be submitted by Mn/DOT to the FHWA Division Office regardless of who is initiating the request. Prior to submittal to FHWA, the request shall be reviewed by Metro Division's Traffic Engineering Office and the region's access manager.

The request should be a standalone document. The referencing of information in other documents (feasibility study, environmental documents) is discouraged. The information from these documents should be provided in the appropriate section of the access request. Excerpts may be included as appendices.

It should consist of an introduction that describes the project and its need. The document should be clearly written for someone that is not familiar with the project, the area, or the state. Vicinity maps are very helpful. There are many cases where the request will be reviewed and approved by someone that is not familiar with the project or the area.

The request shall address the eight policy points italicized below. Some general guidance on what is expected is provided. Typically, the better access request packages have taken each requirement and dedicated a section of the request to illustrate how that requirement is met. Example: Chapter 1 is policy point 1 with its attachments.

7.3.4.1 IAR Policy Requirements

The IAR must satisfy each of the eight policy items described below. Commentary has been provided to elaborate on what is needed to satisfy the policy. Additional justification and explanation may be required on a project-by-project basis. A meeting with FHWA and Mn/DOT should be held to discuss the specific requirements for each project.

1. *The existing interchanges and/or local roads and streets in the corridor can neither provide the necessary access nor be improved to satisfactorily accommodate the*

design year traffic demands while at the same time providing the access intended by the proposal.

Describe the proposed new or revised access and explain the need for the access point. Need must be established by showing: 1) that the current or future traffic cannot be accommodated by improvements to the existing roadway network and the existing interchanges/ramps, and 2) that the traffic demanding the new/revised access is regional traffic (longer trips) rather than local traffic circulation. Capacity required for local traffic (shorter trips) is not an adequate need explanation.

2. *All reasonable alternatives for design options, location and transportation system management type improvements (such as ramp metering, mass transit, and HOV facilities) have been assessed and provided for if currently justified, or provisions are included for accommodating such facilities if a future need is identified.*

Describe the different alternatives considered and why the selected alternative was chosen. This description should include why the layout for the selected alternative was chosen, include the other configurations and if something is prohibiting the use of an alternative design. (Example: Considered a flyover but jurisdictional wetlands prohibits its construction, a loop ramp was considered, but it cannot handle the volume of traffic required.) Cost is usually not the only reason; it plays in the decision, but is not justification for a poor design.

Answer the question, why this design?

3. *The proposed access point does not have a significant adverse impact on the safety and operation of the interstate facility based on an analysis of current and future traffic. The operational analysis for existing conditions shall, particularly in urbanized areas, include analysis of sections of interstate to and including at least the first adjacent existing or proposed interchange on either side. Cross roads and other roads and streets shall be included in the analysis to the extent necessary to assure their ability to collect and distribute traffic to and from the interchange with new or revised access points.*

A traffic and operational analysis needs to be performed that includes an analysis of adjacent segments of the freeway, as well as nearby existing and proposed interchanges. The results must demonstrate at year of implementation and design year the adequacy of:

- Freeway mainline
- Freeway weaving
- Freeway diverge
- Ramp merge
- Ramp/cross road intersection
- Cross roads and other local streets ability to effectively collect and distribute traffic from the new of revised interchange.

Analysis results should be presented in the request at critical points (e.g., weave, merge, diverge, accident sites, HOV lanes) along the affected section of interstate (mainline and ramps) and on the surface street system for both the AM and PM. Show new congestion points that would be introduced by the proposal, and congestion points that should be improved or eliminated, any locations at which congestion is compounded, and any surface street conditions that would affect traffic entering or exiting the interstate. This should be presented for existing, year of opening, and 20-year future design year.

The limits of the analysis on the interstate shall, at a minimum, be through the adjacent interchanges on either side of the proposed access. In urban areas, it is often necessary to consider the two adjacent interchanges in both directions. Distances to and projected impacts on adjacent interchanges should be provided in the request.

The limits of the analyses on the existing or improved surface street system will be the extent of the system necessary to show that the surface street system can safely and adequately handle any new traffic loads resulting from the new/revised access point.

The analysis can be based on the current HCM operational analysis procedures if this methodology is adequate. If the project area is congested or complicated (e.g., significant weaving activity or closely spaced interchanges), micro-simulation will be required. In the Metro Division area, micro-simulation will be required in most cases. FHWA is best prepared to accept and review CORSIM analysis and will be able to respond to requests in a timelier manner. We will accept other commonly used micro-simulation programs if pre-approved in advanced and agreed upon at the initial coordination meeting. The request must contain freeway mainline and crossroad/local street traffic volumes (ADT and DHV) including turning movements for current year, implementation year, and design year, and the number of mainline and crossroad lanes including auxiliary lanes or collector distributor roads.

4. *An accident analysis must identify accident history and rates in the freeway section and surface streets affected and project the crash rates, which will result from traffic flow and geometric conditions imposed by the proposed access. The proposed access connects to a public road only and will provide for all traffic movements. Less than "full interchanges" for special purposes access for transit vehicles, for HOVs, or into park and ride lots may be considered on a case-by-case basis. The proposed access will be designed to meet or exceed current standards for federal-aid projects on the interstate system.*

It should be illustrated that the access connects to a public road and will provide all traffic movements. If a less than "full interchange" is being requested, justification must be provided. It must be shown why the missing traffic movements are not being provided and are not required.

If the interchange is being built in phases where there will be a time where a less than "full interchange" is provided, the phasing and operations should be described in detail.

5. *The proposal considers and is consistent with local and regional land use and transportation plans. Prior to final approval, all requests for new or revised access must be consistent with the metropolitan and/or statewide transportation plan, as*

appropriate, the applicable provisions of 23 CFR part 450, and the transportation conformity requirements of 40 CFR parts 51 and 93.

The proposed new/revised access will affect adjacent land use and vice versa with respect to traffic demand generated. Therefore, the request, including transportation management strategies incorporated, shall reference and demonstrate the consistency of the proposed access with: land use plans, zoning controls and transportation ordinances, and regional and local transportation plans that include the proposal.

6. *In areas where the potential exists for future multiple interchange additions, all requests for new or revised access are supported by a comprehensive interstate network study with recommendations that address all proposed and desired access within the context of a long-term plan.*

If the access request is occurring in a developing area or in an area that has the potential for future interchange additions, it should be shown how this access has been part of a comprehensive interstate network study and is consistent with it. The request must demonstrate that the proposed new/revised access is compatible with other feasible new access points. A reference to the study and brief summary of the study and its recommendations should be provided. Do not attach the study.

7. *The request for a new or revised access generated by new or expanded development demonstrates appropriate coordination between the development and related or otherwise required transportation system improvements.*

When the request for a new or revised access is generated by new or expanded development, demonstrate appropriate coordination between the development and related or otherwise required transportation system improvements.

Show that those proposed new/revised access points driven by private development include commitments to complete the non-interchange improvements that are necessary for the interchange to work as proposed.

8. *The request for new or revised access contains information relative to the planning requirements and the status of the environmental processing of the proposal.*

The request should conform to the plan. The status of the environmental processing should include the type of environmental document and when it was signed. If it has not yet been signed, briefly describe the status and schedule of the document along with its anticipated completion.

7.3.4.2 Basic Information for Traffic Analysis of Added Access to Interstate

Data must be sufficient so that FHWA and Mn/DOT can do an independent analysis. Mn/DOT's Modeling Guidelines and the Advance CORSIM Training Manual are key references that document the modeling requirements for the operational analysis. Specific situations or project may require additional information or requirements beyond what is defined. In urban areas with closely spaced interchanges and heavy congestion occurs, it may be necessary to go beyond the adjacent interchanges.

8.0 Chapter 8 – Alternatives Analysis

The primary purpose for using CORSIM in the context of this manual is to guide the design process and program delivery. To this point in the manual, you have been given a framework for preparing a calibrated existing conditions CORSIM model. The framework for developing a calibrated model leads to the task of analyzing future conditions. The notable exceptions to what is different in analyzing alternatives is that if simulated volumes do not match demand volumes, then the design solution tested does not work. The vehicle mix and calibration parameters identified in the calibration process are carried forward into the future model unless a design element is incorporated to eliminate the limiting condition.

8.1 Alternative Analysis Overview

The alternative analysis process begins when a project is first initiated. At that point, there are a number of issues to be identified and conceptual work that has to occur before a viable set of alternatives emerges for detailed simulation analysis. It is important to have traffic engineering staff part of the initial development of alternatives. The responsibility of the traffic engineer is to bring relevant information pertaining to existing operational deficiencies and to help guide the development of alternatives using planning level techniques. The use of micro-simulation follows this initial scoping process, and tests and refines the project design and should produce the evidence that the design is appropriate and meets Mn/DOT standards.

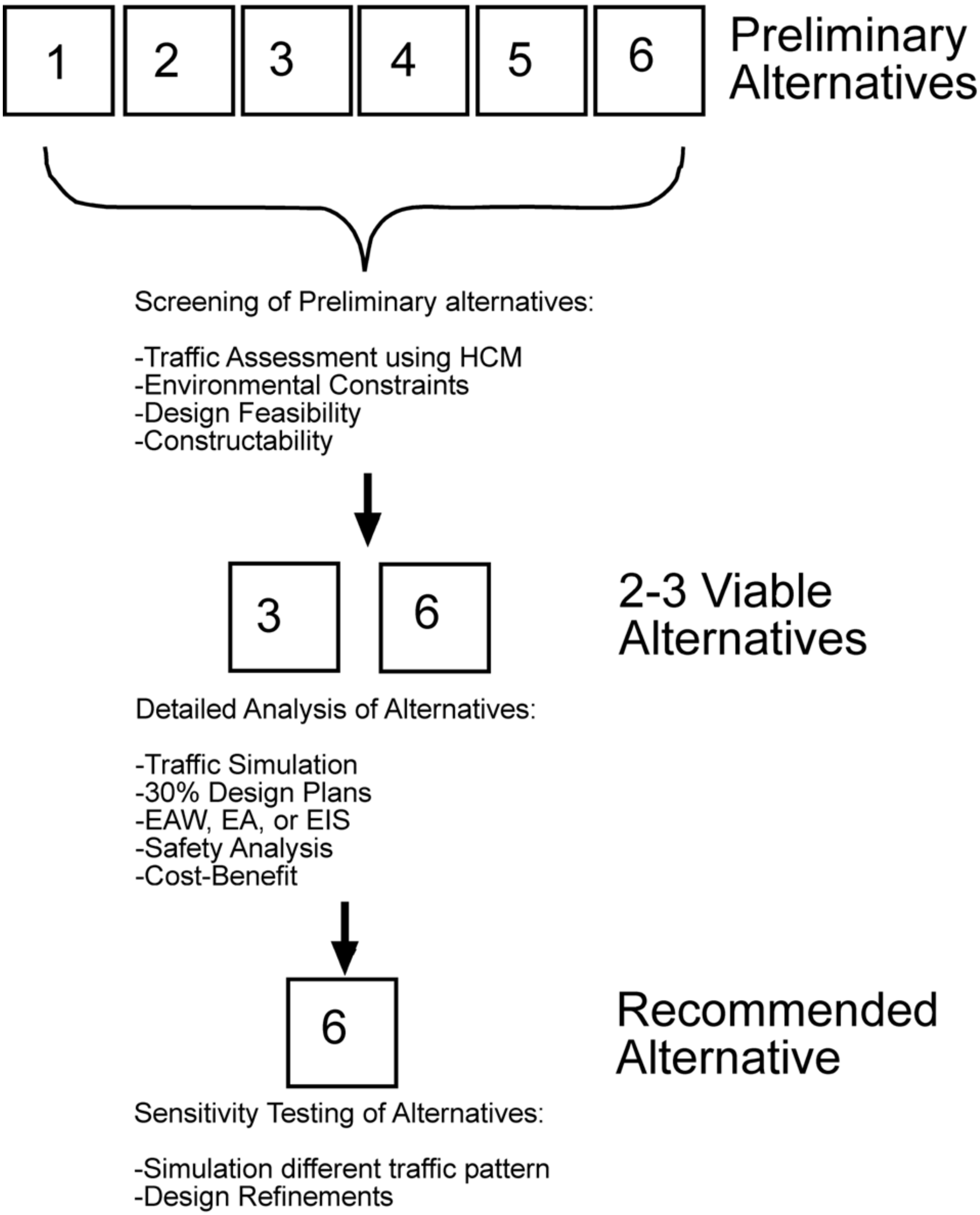


Figure 40 – Alternative Analysis Screening Process

8.2 Alternative Screening Process

During the course of the design process, a number of issues need to be considered. Environmental, design costs, right-of-way constraints, and political constraints to name a few. Along with these design constraints, the ability of the design to carry traffic effectively and safely must be determined. Due to the time commitments of micro-simulation and the uncertainty of developing concepts in the early stages of the design process, it is acceptable to use traffic tools other than simulation to screen the number of design alternatives to a few viable alternatives. We strongly recommend that only two or three viable alternatives be considered. The type of tools includes HCM techniques, per lane volume assumptions, and AASHTO/Mn/DOT design criteria. After a clear process has been established and there has been a general consensus on viable alternatives, the micro-simulation analysis may proceed.

This process may not take as a long as it might seem. If the project is a high priority and has been discussed previously, the simulation modeling process may proceed right away.

8.3 Alternatives vs. Scenarios

The base alternatives include the major elements of a project, such as interchange X is proposed for this location or interchange Y is being modified from a diamond interchange to a partial cloverleaf interchange or a folded diamond. The main alternatives are by definition significantly different from each other.

Scenarios on the other hand are minor modification to the base alternatives; a scenario would not involve a different number of ramp connections, but would involve different auxiliary configurations, basic lanes, and traffic control. These types of changes to a CORSIM model are minor and can be accomplished very easily.

The expectation at this point in the modeling process is that the processing of results is mostly automated; producing results for a scenario run is not equivalent to redoing an entire base alternative.

8.4 Base Alternatives Required for Interchange Access Requests

There are eight criteria that need to be satisfied for FHWA to approve an interstate access request. Generally, these criteria revolve around demonstrating there is a clear need for the proposed project and the proposed project will not adversely affect the operations of the freeway system. It is very important to remember that the IAR can only be approved if the local system cannot be improved to meet traffic demand. In order to prove these main points, an analysis of a number of time frames and build conditions are required. Due to the significant levels of traffic and congestion on the interstate system in most urban areas conflicting with the limitations of HCM techniques, a CORSIM model is usually required.

The timeframes and build conditions are summarized in the following table. In order to determine the effect of the proposed project, baseline comparison is required. The comparison is between the build condition and the no-build condition for the year of opening and the 20-year design timeframe. These times should be assumed, but may vary in unique situations.

Table 5
Interstate Access Request Analysis Requirements

Time Frame	Build Condition		
	Existing	**No-Build***	**Build Alternative(s)**
Existing			
Year Opening			
20-Year Design			

*The No-Build alternative is the existing condition, plus other committed improvements not including the proposed project.

8.5 Sensitivity Testing

The CORSIM modeling process provides an excellent opportunity to determine the strengths and weaknesses of a design. After the recommended alternative has been selected, a series of sensitivity tests should be run on the design. What will dictate the need for sensitivity testing is the uncertainty of the traffic forecasts including total volumes and weaving patterns, if the design is at LOS E or F, or if there is perceived benefit in constructing more roadway because of constructability issues.

The type of design refinements to be considered and analyzed include:

- Auxiliary lanes
- Increasing storage lanes
- Increasing the number of basic lanes
- Traffic signal modifications

8.6 Forecasting Traffic

A significant component to the analysis of alternatives is the development of traffic forecasts. This process is quite involved and relies on estimates and assumptions to determine what the traffic volumes will be in the future. Forecasting techniques include:

- **Regional Travel Demand Models.** The regional models are large-scale models that assign traffic to the roadway system based on desired travel between areas called Traffic Analysis Zones (TAZs) and major roadways that leave the study areas. Within each TAZ, trips are estimated based on the socio-economic information including residential population and employment. Trips are assigned to the roadway network based on the desired destination between zones and the relative congestion on each road. The regional forecast model will take into account parallel routes and divert traffic accordingly. The results from travel demand models require careful review; the estimates of capacity is at a planning level and may not take into account real operational constraints. The Met Council maintains a travel demand model for the Twin Cities metropolitan area.

- **Applying Historical Growth Patterns.** Traffic forecasts are sometimes prepared based on applying historical growth trends out into the future. This type of forecast methodology can be used to compare results from the travel demand model. Strong caution must be used when historical growth is applied; a mature corridor may not grow at a high rate or the growth rate may not take into account realistic system capacities and possible diversions to other routes.

- **ITE Trip Generation Methods.** The Institute of Transportation Engineers maintains a Trip Generation Manual, which contains trip rates for different land use types and sizes. This methodology would involve adding traffic to existing traffic counts based on new development. This method would not take into account background growth outside of the study area.

- **Hybrid of all the above.** It is possible to employ all of these methods to develop traffic forecasts.

All traffic forecasts and methodologies must be submitted to Mn/DOT for review and approval. Contact Gene Hicks at Mn/DOT for traffic forecast information in the metro area.

8.6.1 Time Periods for Future Traffic Demand

The CORSIM modeling process discussed in this manual and in the modeling guidelines/requirements uses 15-minute data over a 3-hour peak period. Forecasting is not a precise science, estimating daily traffic is easier than peak hour traffic, and estimating 15-minute traffic is impossible. In order to analyze 3-hour periods in CORSIM for the future condition, you are factoring the 15-minute databased on the future peak hour divided by the existing peak hour volume. This is similar to applying peak hour factor in HCM or other analysis methods – in essence we are applying the existing peak period traffic pattern to the future in order to analyze the build up failure and recovery of the system.

Appendix A

General Modeling Guidelines

General Modeling Guidelines

Rev July 9, 2003
N:/traffic/modeling/freeway/modeling guidelines rev.doc

The following modeling guidelines have been developed jointly by Mn/DOT Metro Traffic and FHWA to clarify the modeling process, to insure a useable product, and to meets federal operational analysis requirement for an Interstate Access Request.

Microscopic Model

CORSIM is a micro-simulation program that is currently accepted by Mn/DOT and FHWA for operational analysis to satisfy Interchange Access Requests. Other micro-simulation programs would be considered if the purpose and complexity of the project justifies the application of another model. Justification needs to be discussed and approved by FHWA, Mn/DOT, and project manager prior to use.

Modeling Meeting

The model limits and time periods will be determined at the initial modeling meeting. Consideration will be given to project type and location, and whether or not it is located in a congested corridor. Changes should be discussed and agreed upon by project manager, FHWA, and Metro Traffic.

Assumptions:

1. The modeling analysis will be performed using the latest version of CORSIM.
2. Model should run without errors. The model should work on a balanced traffic network that has reach equilibrium.
3. The basic traffic study, at a minimum, should produce traffic measures for the current year, the opening year, and the 20 years into the future for the existing geometrics. The work will also include the modeling and analysis of the proposed geometrics for the opening year and the 20-year future design year.
4. The boundary conditions, at a minimum, should extend one interchange beyond the project limits. Bottleneck conditions or congestion at the boundary conditions may require modifications to the model to get the simulation to match the existing traffic conditions.
5. Simulations should be performed for the AM and PM peak periods. Typically, the peak periods run from 6:00 to 9:00 a.m. and 3:30 to 6:30 p.m. unless the study methodology determines otherwise.
6. The default vehicle type will be modified as outlined in the CORSIM Calibration Parameters write-up.
7. The current fleet composition (i.e., truck percentages) will be used.
8. Freeway traffic shall be developed based on 15-minute values for a typical day unless otherwise specified in the initial modeling meeting. The data should include all mainline and freeway ramp detection stations within the project boundaries for both peak-periods. Data should be taken from the previous year whenever possible using late September through October data. The traffic demand data should represent a typical day (Tuesday, Wednesday, and Thursday). The data should be screened for and exclude those days where weather, incidents, and holidays influence the traffic values. Traffic data from the instrumented system should be considered raw data that has not been scrubbed or analyzed for poor or missing data.
9. Turn movement counts that were taken within the last two years will be accepted.

10. Verify that reasonable free flow speed have been entered into the segments and ramp links by checking the link properties.

11. The traffic signals located at the top of the interchange ramps and within the project area shall be coded into the model using current timing information.

12. Ramp metering will be coded using the current ramp metering timing and only applied to the ramp meters currently operation during each peak period.

13. The link node diagram shall be created on a base map in real work coordinates.

14. Lane schematic shall be created that graphically represent the network and includes all the key design features.

15. O-D matrixes must be developed for all freeway models.

16. The existing modeling will be calibrated for a typical weekday (Tuesday, Wednesday, or Thursday) during late September through October. Model has reached calibration when the simulated mainline volumes are within 10 percent of detector values, speeds are within 20 percent of calculated speed, and ramp queues are within a reasonable range.

17. A minimum of five (5) simulation runs will be conducted. The average of five runs will be used to assemble the MOE summary table. The random seed numbers used will be recorded and submitted.

18. Unique project specific features (ITS, transit, high occupancy vehicle, etc.) will be incorporated in the model as determined at the initial modeling meeting.

19. The forecasted numbers should be submitted and approved to Metro Planning (Gene Hicks) gene.hicks@dot.state.mn.us prior to use.

20. Quality control procedures shall be inplace to ensure the model has been accurately developed.

21. The model shall conform with the process outlined in the Advanced CORSIM Manual.

Deliverables

The modeling deliverables are briefly summarized below and do not include the detailed information or format. This information can be found in the Advanced CORSIM Manual.

1. Scenario write-up
2. Link node diagram
3. Lane schematics
4. QA/QC sheets
5. Balanced traffic demand dataset for freeway volumes and arterial turning movements
6. O-D matrixes
7. CORSIM (filename.trp files) and Synchro files (filename.sy6)
8. Calibrated model and supportive statistics
9. Random seed numbers
10. Freeway and arterial summary tables and graphics of the MOEs
11. Alternative summary table and/or graphics of MOEs

Resources and Information Available

1. External clients can extract freeway detector data (volume, density, and speed) and ramp control data at the Mn/DOT's Water Edge facility. The data extraction workstation is located on the 2nd Floor in Traffic Engineering. We request that data extraction be conducted during off-peak hours and on working days. Data should be screened for weather and major incidents during late September through October. Instructions are available at the workstation and will be available on-line in the near future.

2. Current timing and phasing information for any traffic signals operated by Metro Division is available by contracting the Metro Signal Operations at:

   East Metro – 651.634.2134 or
   West Metro – 651.634.2131

3. Turning movement counts are available on the Mn/DOT Metro Division web site: http://www.dot.state.mn.us/metro/warrant or by contacting Metro Traffic at 651.634.2144. Do not use traffic or turning movement counts more than two (2) years old.

4. Fleet composition (i.e., truck percentages) are available by contacting Metro Planning at 651.582.1402.

5. Forecasted values should be reviewed and approved by Metro Planning. Submit the spreadsheet, growth rates used, and trip distribution assumptions to: gene.hicks@dot.state.mn.us.

6. Forward modeling files (CORSIM and Synchro) and supportive information and data to Metro Traffic at the following e-mail address: kevin.sommers@dot.state.mn.us. Carbon copy linda.taylor@dot.state.mn.us.